NATIONAL ACADEMY OF SCIENCES

OF THE UNITED STATES OF AMERICA

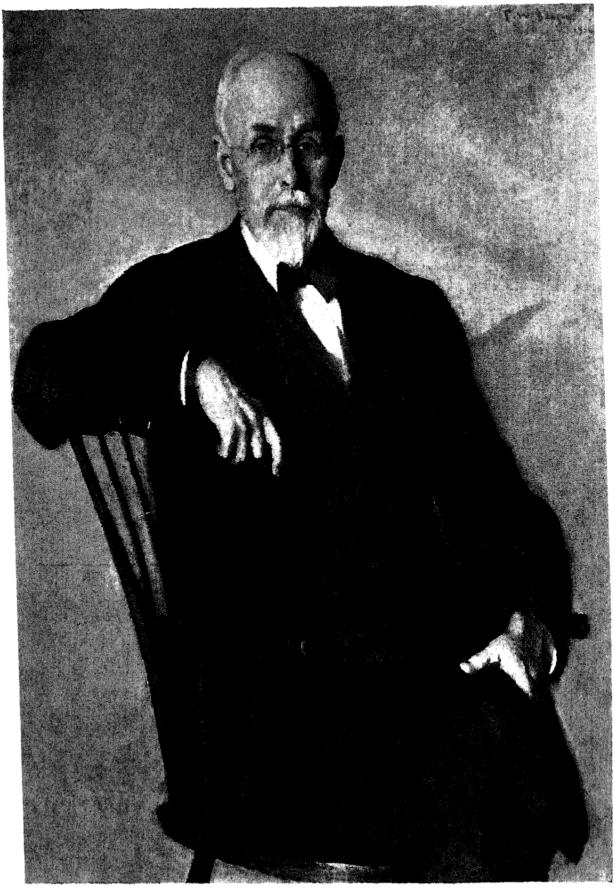
BIOGRAPHICAL MEMOIRS

VOL. XVII

CITY OF WASHINGTON
PUBLISHED BY THE NATIONAL ACADEMY OF SCIENCES
1937

CONTENTS

Portrait of Edward Sylvester Morse
painted by Frank Benson
now in the Peabody Museum at Salem



Edward S. Morse

NATIONAL ACADEMY OF SCIENCES

OF THE UNITED STATES OF AMERICA

BIOGRAPHICAL MEMOIRS

VOLUME XVII—FIRST MEMOIR

BIOGRAPHICAL MEMOIR

OF

EDWARD SYLVESTER MORSE

1838–1925

BY

L. O. HOWARD

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1935

EDWARD SYLVESTER MORSE

1838–1925

A Biographical Sketch

(With Some Account of His Scientific Activities)

BY L. O. HOWARD

To those who read this, I owe an apology and an explanation. They will be disappointed. There should be a book about Morse. One will be written some day. But I am limited by the rules of the Academy to six thousand words and I am not competent to do justice to the latter part of his career. I must confine myself largely to his scientific life and doings. A man who was elected to the National Academy of Sciences at thirty-eight, and president of the American Association for the Advancement of Science at forty-eight, must have been a force in American science, and therefore it is that part of his life that a Biographical Memoir for the National Academy of Science must deal with especially. The rest of his useful and remarkable life has been, or will doubtless be, dealt with much more competently by others.

Edward Sylvester Morse was the son of Jonathan Kimball and Jane Seymour (Beckett) Morse, and was born at Portland, Maine, June 18, 1838. He married June 18, 1863, Ellen Elizabeth Owen (1837-1911) of Cape Elizabeth, a little town across the harbor from Portland. Two children were born; Edith (Mrs. Russell Robb of Concord, Mass.) and John G., now of Ripley Hill Road, Concord, Mass. Professor Morse's father was a business man of Portland, and was descended from Anthony Morse who came from England soon after Plymouth and Salem were settled.[1] There is no evidence apparently of

[1] Anthony Morse of Wiltshire, England, came to America in 1635 and settled in Newbury, Mass. He died in 1678. His son, Anthony, born 1662. His son Stephen [son of Anthony] was born 1695. His son Thomas was born 1721. His son Thomas [son of Thomas] born 1749. His son Thomas lived in Haverhill, N. H., but the date of his birth is not known. His son, John [Jonathan] Kimball, was born in 1802 and Edward Sylvester, born 1838, was his son. [Data supplied by John G. Morse.]

scientific tastes or accomplishment on the father's side, although there is a strong artistic trend. E. S. Morse's brother, George Frederick Morse, although not a professional, painted landscapes all his life, and left hundreds of canvasses, all of much merit, although they were painted simply for diversion. Samuel F. B. Morse of telegraph fame, said to be a distant relative, of the same ancestral stock, was, as is well known, a painter by profession, as also was his son, Edward Lind Morse. But very likely the famous inventor's great invention indicates a happy and unusual mixture of artistic and scientific tastes. Surely E. S. Morse had this combination for he was one of our first zoologists, drew all of his own illustrations, illustrated his many public lectures with wonderfully clever blackboard drawings, became an authority on a branch of Japanese art, and for nearly half of his life ranked as a leading authority on that subject. But on Morse's mother's side, it was different. She claimed to have descended from Thomas A'Becket, Archbishop of Canterbury. She had decidedly scientific tastes. She had relatives who were well known literary people, and John G. Morse writes me that she was "interested in all branches of science. She lived until 1896 and was thus able to witness her son's success."

Laying aside however, all questions of inheritance, Morse was a born naturalist. W. H. Dall (*Science,* Feb. 5, 1926) states that at the age of 13, he had amassed "a notable collection of shells." His early training was in the common schools of Portland, but he also attended the Bethel Academy at Bethel, Maine, and the Bridgeton Academy at Bridgeton, Maine. After his father's death in 1860, his mother moved the family to Gorham, Maine, about nine miles southwest of Portland. He continued to live there until after he was married. Dr. T. S. Palmer has called my attention to a very interesting obituary notice in the *Maine Naturalist,* Vol. 4, pages 155 to 158. With it is a portrait of Morse at the age of 16, reproduced "from copy in library, Portland Society of Natural History." It appears from this article that he joined the Society at the age of seventeen, and that a year later he was made one of its board of managers. In 1866, the Society removed its quarters and Morse was engaged to install and renovate the collection. While he was engaged in

this work, the great Portland fire occurred and destroyed the building. Morse always was proud of the fact that he himself saved the portrait of Humboldt, painted by Wright and given to the Society by Longfellow.

Morse had joined the Society after leaving Bethel and Bridgeton Academies and, at about the same time, he was engaged as draftsman in the locomotive shops of the Maine Central Railroad. Apparently the most careful study that has been made of this formative period of Morse's career by a competent naturalist, is summed up by J. S. Kingsley in a very excellent article on pages 549 to 555 of the *Proceedings of the Academy of Arts and Sciences* LXI (May 1925-1926). I have already referred to the very excellent account by W. H. Dall, but that is shorter and says less of his very early days. And those must have been great days. The boy was earning his living, and more than that, he was saving his money to be used for a broader education soon. He was a draftsman and a good one, and that would help greatly in his future career as a naturalist. And he belonged to the Portland Society of Natural History, then in full swing. Here he came in contact with Dr. William Wood, Charles Fuller, and the Reverend Edwin C. Bolles, all enthusiastic naturalists, and encouraged by them, he began the study of land shells of the state. These studies soon brought him into correspondence with the leading conchologists of the time—Drs. Michaels, A. A. Gould, Amos Binney and his son William G., as well as others. In his spare hours, he visited the woods of the region and the islands of Casco Bay, and found there several new species of land snails, descriptions of which were published in scattered papers. The substance of all of these was brought together and published a number of years later in a well illustrated paper, issued in the first volume of the *Journal of the Portland Society* in 1864 (Kingsley).

I have little doubt that while working away at his draftsman's duties, and even more enthusiastically with his land shells and other things, at the Society, Morse had his eyes fixed on the Lawrence Scientific School at Harvard University, and its professor of natural history, Louis Agassiz, who held that position from the foundation of the school in 1848. At last in 1859, at the age

of twenty-one, he had saved enough money and went to Cambridge, arriving there at about the time of the laying of the corner stone of the Museum of Comparative Zoology, long known as "The Agassiz Museum." It is true that Mrs. Agassiz does not mention Morse in her two volume work on her husband, but he worked enthusiastically in the school from 1859 to 1862. Then he was made an assistant in the Museum of Comparative Zoology. Among his fellow students were Alpheus Hyatt, A. S. Packard, Jr., F. W. Putnam, S. H. Scudder, and A. E. Verrill, all to become more or less intimate friends and colleagues, and all to become famous men of science. Interesting lights are thrown on those early days at Cambridge in the published addresses by Morse and Packard at the Memorial Meeting of the Boston Society of Natural History on the death of Hyatt. They will be found in the Proceedings of the Boston Society, Vol. 30, pages 415 to 425.

F. W. Putnam was a resident of Salem, and was greatly interested in the so-called Essex Institute of that city. The Institute had founded a museum that contained large collections in natural history brought home through the years by the famous Salem ships. Putnam induced his fellow students, Hyatt, Packard, Verrill, and Morse to work at these collections, Morse on the shells, Packard on the articulates, Hyatt on the sponges and on geology, and Putnam on the vertebrates and ethnology. Whether they went to Salem to live a year or so earlier or later, makes little difference, but, when George Peabody gave the Institute $140,000 and the well known Peabody Museum was founded in 1867, all of them but Verrill (who had gone to Yale), were placed in definite charge of these subjects in the Museum.

In the early 1860's there was evidently trouble and some dissatisfaction, especially among the young assistants in the Museum at Cambridge. They were paid very little and were given no credit for their individual work during Museum hours. The Civil War was on and the whole country was greatly disturbed. Packard, for example, entered the northern army as an assistant surgeon in 1864 and saw service in Virginia. Burt Wilder also entered the northern army as an assistant surgeon. Morse went back to Gorham, nine miles southwest of Portland and on his

birthday, June 18, 1863, he was married. I am told by his son, John G. Morse, that he tried to enlist in the army of the north but was rejected on account of his teeth. Evidently they were not fitted for the biting of the cartridges so necessary at that time. He stayed in Gorham from 1863 to 1866, working hard on his shells, and at the Portland Society of Natural History doing much drawing on wood blocks for engraving and thus supporting his family. This information is sent me by John G. Morse, but Mr. L. W. Jenkins of Salem writes me that Morse was an assistant at the Cambridge Museum from 1862 to 1866.

At all events we find the group of ardent young naturalists all working enthusiastically in the Peabody Museum at Salem in 1867. And how they must have worked, and with what enthusiasm! The first edition of Packard's great "Guide to the Study of Insects" was published in 1869. Then also the four of them, a year earlier (1868) founded *"The American Naturalist"* which for ten years was published at Salem.

The founding of the *"American Naturalist"* was an important event in Morse's life and it was a high light in the progress of American natural history. The articles were sound, written by the best men in America, and they were understandably written; its policy was broad and its founders and editors were full of enthusiasm. It was well illustrated for that time, thanks largely to Morse's skill as a draftsman. Nothing of the kind, for example, has ever been better done than his full-page plate in black and white illustrating Packard's "Home of the Bees" in Vol. I (facing page 378). There is no doubt that this admirable magazine inspired and, in fact, made many young naturalists, some of whom were to become famous.

It was during this time that Morse entered the lecture field. It was the day of the lecture lyceums. He was a charming speaker, full of humor, of very broad knowledge, and he illustrated his lectures by extraordinary blackboard sketches. He drew admirably and rapidly and he drew with both hands at once—a bit of chalk in each hand. No other scientific lecturer had his facility in this way, and his talks were very popular. Evolution was becoming a greatly discussed subject at that time and Morse, like nearly all of Agassiz's best students, was an

ardent evolutionist, in spite of his great teacher's strongly expressed opinions.

It was probably because of the group of enthusiastic young workers living at Salem, that the 1869 meeting of the American Association for the Advancement of Science was held there. All of these men were on the local committee. In the absence of Joseph Lovering, Putnam acted as permanent secretary, and as we well know, four years later he was made permanent secretary, and held the office for nearly a quarter of a century. All of the group were always prominent in the great national association, but Morse was the first to reach the presidency. He was elected to that office in 1886 and read his address as retiring president at the New York meeting of 1887. It comprised an astonishing summary of the work of American naturalists on the doctrine of evolution.

And there soon came another striking event in the development of American biological science (or, call it, the study of natural history, if you like) and that was the summer school at Pennikese in 1873. There is no reason why we should spend many words here upon that wonderful summer. It was the first of the summer schools for naturalists ever held in this country and it has been written about and lauded in hundreds of journals. It was a marvelously fine and successful experiment. The young men and women who went there (they were limited to fifty) became, most of them, the great teachers and workers of the next thirty or more years. Of all that has been written about that wonderful summer of 1873, nothing that I have read is so good, so satisfactory, as David Starr Jordan's article in the *Popular Science Monthly* for April, 1922, entitled "Agassiz at Pennikese." Jordan himself was there—the youngest of the students. Morse was there as one of the teachers. What an inspiration for many years the memory of that summer must have been. The men of my generation have always envied them, and will continue to do so as long as any of us live. Agassiz died the following December and the Pennikese people gradually scattered. A very interesting article by Morse himself entitled "Agassiz and the School at Pennikese," will be found in *Science* of October 12, 1923, pages 273 to 275.

We might as well give here the record of the especial group of six we have been considering with reference to the National Academy of Sciences. Verrill and Packard were elected in 1872, Hyatt in 1875, Morse in 1876, Scudder in 1877, and Putnam in 1885. It is well known what all of them accomplished. Morse continued to work at Salem. He became a truly great museum man. In 1870 he was lecturer on zoology at the Maine State College at Orono, and from 1871 to 1874 he was professor of comparative anatomy and zoology at Bowdoin College. Bowdoin, by the way, gave him an honorary doctorate in philosophy in 1871, and many honors came to him rather rapidly. I have not space to list them here; they were very numerous. But they are given in some detail in "Who's Who in America," vol. 13 (1924-1925), and in "American Men of Science," 3rd edition (1921).

In 1875 the Appleton Company of New York published Morse's "First Book on Zoology." It was not a large book (190 pages), but it contains 158 numbered illustrations and some of these are reprinted in the final chapter "On Classes and Subkingdoms." All of the illustrations are from line drawings done by Morse himself. It was a book for young students and it was admirable. I wish that I might have had it at that time, for I was then in the middle of my course at Cornell. I am sure that it would have helped me greatly, but I never saw it until years later, although Burt Wilder, my teacher in zoology, was a fellow student with Morse at the time of the outbreak of the Civil War. The book was widely read and very flatteringly reviewed. It is perhaps an interesting sidelight on Morse's artistic tastes and reading that a quotation printed on the title page is from one of Hogarth's letters to Ellis.

This will be a good place to summarize Morse's Salem connections and positions. I owe the following exact statement to Mr. L. W. Jenkins, assistant director of the Peabody Museum:

"He joined the Essex Institute in 1864. He was: curator of Radiata in 1867; curator of the natural history department 1869-1872; curator of zoology 1876-1888; member of the council 1888-1893; vice-president 1894 until death; curator of science 1900 until death.

"He came to the Peabody Academy of Science (now the Peabody Museum) as assistant in 1867. He was curator of Radiata and Mollusca 1868 to 1870, director 1880 to 1916; director emeritus 1916 until death."

Now we must consider briefly just what Morse had accomplished scientifically down to the period when he was soon to go to Japan and shortly thereafter begin a line of work that led him far from natural history and absorbed in large measure the rest of his remarkable life. Dr. Dall in his all too short article in *Science,* to which we have already referred, says after mentioning his first paper on Brachiopods, 1862 ("a subject on which he later made notable contributions"). "His first paper to attract particular attention was devoted to some very minute land shells of Maine, illustrated by his own drawings, and proposing new generic names for several of them, based on anatomical characters. This paper, published in 1864, was the precursor of a long series of studies by Bland, W. G. Binney and Pillsbry which have revolutionized the study of the land shells."

Thus we have work published by a youngster still in his early twenties that sixty-one years later, with a thorough knowledge of the work and writings of the intervening period, Dall, a great master in Malacology says "revolutionized the study." This alone should establish a great reputation. But the Brachiopoda! He began to study this interesting group as early as 1860 or perhaps even earlier. Naturally being interested in shells, he first thought of them as mollusks, but later decided that on the contrary they belonged to the Vermes in spite of the shell. The old group Mollusca was being broken up and the terms conchology and conchologists were soon to be largely abandoned. Morse turned from a study and classification of shells into the study and classification of the animals that made the shells, and he was one of the foremost American workers in the field, recognized as such by all zoologists. His long paper entitled "The Systematic Position of the Brachiopoda" read before the March 19th meeting of the Boston Society of Natural History and published in volume 13 (1873) shows the depth and breadth of his knowledge of the subject and of the work of Leuckart, Gegenbauer and the

then recent European zoologists, and piles up a conclusive mass of facts and arguments.

Kingsley (Loc. cit.) has this to say about Morse's work in zoology:

"Possibly his most important papers were those relating to the Brachiopoda, a group which, when he began to study it, was all but universally regarded as Molluscan, rather closely related to the oysters and the clams. Almost immediately he saw the bearing of certain facts of structure, the significance of which had been overlooked by his predecessors. As these animals have two halves or valves to the shell, this resemblance to clams had been observed all along. Morse showed that this was not a true resemblance for the valves of the clam are right and left, while those of the Brachiopods are dorsal and ventral. Then he took up the study of the internal organs and the development of the eggs, making trips to Eastport and to North Carolina for his material. Every fact he found confirmed him in his conclusions, now universally accepted, that these animals are far more closely related to the common earthworm than to any mollusk. Less striking, but important was his study of the ankle bones of birds, in which he showed that a slight splint was in reality one of the separate bones which occurs in the whole group of reptiles."

But, as his studies of the Brachiopods proceeded, he found that he needed to study many more forms. He had been to the Bay of Fundy, to the Gulf of St. Lawrence and to Beaufort, North Carolina, and only one species was to be found at each of these places. But thirty or forty species were known to occur in Japanese waters. So he went to Japan and established a little seaside laboratory. He had been there only a few days when a professor from the Imperial University called and told him that he had heard him lecture at the University of Michigan and invited him to give the same lecture before the students at Tokio. He countered Morse's statement that he couldn't speak a word of Japanese by the statement that all of the students had to know English before they were admitted to the University. The lecture must have been a great success, for in two weeks he was offered a two years' engagement as professor of zoology. As his public lectures in the United States had been arranged for the coming

winter, he had to stipulate for a five months' leave of absence from Japan which was arranged. It is interesting to note that during that absence, he collected 2500 books and pamphlets for the Imperial University Library. And first he arranged for the University to start a seaside laboratory at Enoshima and I am interested to know that my old-time fraternity brother at Cornell, Riokichi Yatabe, then teaching botany at Tokio, accompanied him on his arrangement trip.

Coburn says "Morse opened a laboratory at Enoshima and was invited to teach zoology at the Imperial University. His tenure of professorship (1877 to 1880), witnessed the introduction among the Japanese of modern methods of collecting and classifying objects of natural history. From the train between Enoshima and the capitol, Morse's keen eye detected some shell heaps ignored by the native savants. His excavations of these kitchen middens with their prehistoric artifacts was an epoch in the annals of anthropology. While visiting Yezo and the Hokkaido, Morse first saw the Ainos and perceived their probable kinship with the brunette white races."

In his teaching of zoology he met with the greatest success. All of us who knew him can readily understand the vivid interest he aroused in the extremely clever and ingenious Japanese students. It has been said that the world owes directly to Morse the admirable scientific careers of Mitsukuri and Ishikawa, and a long line of distinguished students followed, among whom Kingsley mentions Watase, Oka, Goto, Myabe, and Yatsu, and there was a small army of others. In the preface to his delightful "Japan Day by Day" (Houghton Mifflin and Co., 2 volumes, 777 illustrations, 1917), Morse distinctly states; "I first visited Japan solely for the purpose of studying various species of Brachiopods in the Japanese seas. While pursuing my work in a little laboratory established at Enoshima, I was invited by the educational department to take the chair of zoology at the Imperial University."

The little seaside station at Enoshima was one of the first marine biological laboratories in the world. Possibly Naples, Woods Hole, Roscoff, and Sebastopol, preceded it a bit, but the long list beginning with La Jolla came much later. It was primi-

tive and small, but the living aquatic material was superabundant. Morse bubbled over with delight at the mass of interesting specimens brought in. Mitsukuri, sent down from the University with his expenses paid, worked with him almost from the first. In "Japan Day by Day," Morse has in volume one a chapter (VII) entitled "Collecting at Enoshima." Of this chapter not more than a half dozen of the thirty-seven pages have anything to say about collecting, and yet the book is based closely on his daily diary kept through his three visits to Japan. Does that not indicate how Japan and its strange and admirable people and customs were arousing in him interest even stronger than his interest in zoology? In asking this question perhaps I do him an injustice. He may have culled from his notes only such things as he thought would make up a book interesting to most people, and there may have been loads of interesting and important zoological notes that he did not use.

But when we come to think of the matter very carefully, it is not difficult to see that, entirely aside from the great interest aroused by the absolutely novel environment—an interest especially keen in a man of Morse's overflowing enthusiasm, there were very sound, even weighty, reasons why Japan, its art, its strange culture, were allowed rapidly to absorb more and more of his deep interest and to push zoology into the background temporarily. I write this word "temporarily" with full intention. I know that Morse never lost his keen interest in zoology. It continued to the end, and, as will be seen, from the appended bibliography, he continued to write on zoological subjects, naturally less frequently than in his early manhood, but quite until the year of his death. All through his life I really think that he thought that he was (as he therefore actually was) an ardent naturalist drawn away for the time being by the art and anthropology studies that thrust themselves upon him. He could not neglect his marvelous opportunities as did many of the foreign scientific men who were brought to the Imperial University to teach in those early days. His very last paper published the year of his death, was a scientific paper having to do with shells. I am sure that he was influenced by the extreme views of his friend, Dr. William Sturgis Bigelow, on

this subject; at least it must have helped him to think of them whenever he was troubled by doubts. In fact, Morse writes in the preface to his "Japan Day by Day," that the book would never have been prepared for publication had it not been for a letter from Dr. Bigelow. Morse wrote him that he had a long leave and would finish a number of studies on Mollusks and Brachiopods and received the following reply:

"The only thing I don't like in your letter is the confession that you are still frittering away your valuable time on the lower forms of animal life, which anybody can attend to, instead of devoting it to the highest, about the manners and customs of which no one is so well qualified to speak as you. Honestly now, isn't a Japanese a higher organism than a worm? Drop your damned Brachiopods. They'll always be there and will inevitably be taken care of by somebody or other as the years go by, and remember that the Japanese organisms which you and I knew familiarly forty years ago are vanishing types, many of which have already disappeared completely from the face of the earth and that men of our age are literally the last people who have seen these organisms alive. For the next generation the Japanese we knew so well will be as extinct as Belemnites."

The point made by Dr. Bigelow appealed to Morse as "overwhelming and unanswerable," and he laid aside his plans of work on the sea animals and put together his voluminous notes on the Japanese for his charming two volume work. I think that he must have found a consolation also in the final paragraph of a letter he received from Charles Darwin which read: "Of all the wonders of the world the progress of Japan in which you have been aiding seems to me about the most wonderful." (See "Life and Letters of Charles Darwin.")

Morse often spoke of his "three trips to Japan." As a matter of fact his first engagement with the Imperial University covered two of these trips since he first went over in 1877. He returned to the United States in 1878 for five months to fulfill his lecture engagements, returned to Japan in the same year and returned to his own country in 1880. And his mind was full of Japan. He gave many lectures (including a course

before the Lowell Institute in 1881) about the country, its people, and its arts, and apparently he did little with his formerly beloved Mollusks and Brachiopods although he published several broad scientific papers. Japan was constantly in his mind and in 1882-1883 he was able to return there. It was largely to this third journey that we owe his delightful book "Japanese Homes and Their Surroundings" (Boston 1888), the preface to which he wrote in Salem in 1885. This book is the result of a wonderful and very intimate study of the Japanese home of that time, illustrated by more than three hundred of his remarkable line drawings and carrying an elaborate glossary and index. It must have permanent and very high value as an extremely close and enlightened study of certain important aspects of the "Kultur" of a rapidly changing race.

Soon after his first arrival in Japan, Morse became interested in everything bearing on the ancient culture of the people. This was shown in the epoch making discovery and excavation of the Omori kitchen midden. Implements and pottery were found there. In 1878 he wrote that he was starting a collection of pottery. This is what F. S. Kershaw, Keeper in the Department of Chinese and Japanese Art in the Boston Museum of Fine Arts wrote in the *Bulletin* of the Museum for February 1926:

". . . the sequel proved him a 'natural born collector,' whose ardor for the kinds of pottery he wanted never diminished. The kinds he wanted are those bearing potters'-marks and specimens from every kiln and for every kind of use, all in the tradition of that old Japan of which he so keenly lamented the passing. His means were modest, but his acumen in searching the records, his persistence in following clues, his extraordinary tactual and visual memory and his capacity for making friends stood him in good stead. Within nine years it could be said of his collection with truth that it surpassed any other in number of specimens and that it was by far the most widely representative of the potters of Japan, of their kilns, the forms of pottery they made, and the provinces in which they lived."

In 1890 this great collection was deposited with the Boston Art Museum and two years later the Museum bought it, Morse

being made Keeper of Japanese Pottery and holding the office for the rest of his life. At the time of this appointment he was Director of the Peabody Museum at Salem and of course retained that position. As Kershaw has pointed out ". . . he was thus enabled to use his wide knowledge of Japan, ethnological and artistic, to the advantage of both institutions." In Salem he brought together a department in the Museum illustrative of the manners and customs of the Japanese. In Boston he was working on the preparation of his monumental "catalogue of Japanese pottery."

But during these years, he was also doing many other things. He was one of the most active men alive. In 1902, he published a book entitled "Glimpses of China and Chinese Homes" and in 1906, another called "Mars and Its Mystery." That he should have written the first of these seems natural enough after the success of his volume on "Japanese Homes and Their Surroundings" published sixteen years earlier. The same characteristics made the book on China most interesting. It was illustrated by very many of Morse's charming pen and ink sketches, reproduced directly as he states, from his note books. There are sixty-six of these sketches all drawn with that unusual combination of artistic appreciation and scientific accuracy so characteristic of the man. In his introduction he points out that most of the material appeared first in a series of articles in the *American Architect* under the title "Journal Sketches in China." It was largely on the basis of this work that he was elected a member of the American Institute of Architects and an honorary member of the Boston Society of Architects.

The volume on "The Mystery of Mars" was acknowledgedly written "for the general reader." Morse's attention to the subject was attracted by the controversies then rife with regard to the strange markings on Mars and largely by the announced discovery and interpretation concerning Mars originating from Mr. Percival Lowell and his personally founded observatory at Flagstaff, Arizona. Morse had known Lowell for many years. They had both lived in Japan and had written about that country and its customs. Moreover, Morse had visited the Lowell Observatory and every night for thirty-four consecutive

nights, he was in the observer's chair, several times each evening, making his own observations of Mars and his own sketches of what he saw. We never thought of calling him an astronomer, but he was a scientific man and a student, and he made a deep study of everything that had been written on the subject and brought it all together in a very readable book of about two hundred pages. The book was taken seriously and was read not only by very many intelligent people, but by astronomers all over the world, and that he was elected to honorary memberships in the astronomical societies of France and Belgium was due solely to this book.

The publication, however, on which he spent his most serious labor, and of which he was very proud, was his great "Catalogue of Japanese Pottery" first published in 1891. It was "scholarly, discriminating, and readable" (Coburn). Later it was translated into Japanese and published by the Japanese Government.

We have now finished our necessarily short account of his main activities. But Morse was a man of very many sides. He published articles on many subjects, and was a very frequent writer to the newspapers on current and other topics. I think that the *Boston Transcript* and its readers must have missed him greatly. Coburn lists archaeology, anthropology, architecture, ceramics, ballistics, folk-lore, astronomy, music, archery, and numismatics. And his articles were never superficial or casual. It will be impossible for any man of the present generation who did not know him personally to form any idea of the extraordinary charm of his personality. To hear him lecture was to be very greatly interested and impressed, but to sit down and talk to him would make him your loved and admired friend for life. He had a very keen and very beautiful humor that was apparent to almost everyone, from those of high position down to the street laborer. I remember once at a big National Academy of Sciences dinner at New Haven, I arrived early and found ex-President W. H. Taft sitting alone in the anteroom waiting for the company. I joined him and we talked a bit on the non-exciting subject of genealogy of the Howard family (Taft's grandmother was a Howard). Then

the door opened and in came Morse. The ex-President said with great relief: "Here comes Morse! Ask him over to tell us one of his fine stories."

There is no doubt about it; Morse was one of the most interesting and remarkable Americans of his period. Dr. Dall's closing words (*loc. cit.*) may well be quoted:

"The salient characteristics of Professor Morse, apart from his devotion to science and love of the beautiful in art, was his boyish enthusiasm which captivated all who knew him. The versatility of his interest was unbounded, his love of fun overflowed at every opportunity; to meet him was to find a welcome. The world was brighter for his presence."

A. P. Morse of the Peabody Museum writes apropos the extended bibliography of E. S. Morse to which we have referred the following very apt statement: "Professor Morse's contributions to the daily press were frequent and numerous on all such subjects as would naturally be grouped under the head of civics, including art, customs, economics, education, ethics, government, politics, religion, health matters, and, especially in his later years, noise. Morse was a many sided man who found the world an extremely interesting place in which to live and who did his best with notable success to make it even more so for his fellow sojourners."

Professor Morse's closing years were spent at his home at Salem. His son writes me that he was very active up to the time he was eighty-five years of age, then they began to notice a marked change, he was becoming decidedly hard of hearing and his memory failed him in small things, although he recalled perfectly scientific facts and the important things of past years. He stayed at home and was sitting in his arm chair in his library when he had a stroke. This was on the 16th of December, 1925. Four days later he passed away. He had been unconscious during all four days.

The writer of this biographical sketch acknowledges that when he took up the task, he, as a member of the National Academy of Sciences had the idea that most of the published notices about Morse had not given enough attention to his major work as a biologist—a man of science—and that that

aspect of his life should be displayed more prominently. But now looking over his whole career, it is well that he led his life as he did. It was not a pity that he allowed himself to go off into his oriental studies. It was not a pity that he did not take them up at the start. He led two men's lives and accomplished results that could hardly be accomplished by two resourceful, ardent, magnetic and forceful individuals. So it is a very remarkable, almost unique character we have been considering.

Acknowledgments. The writer has been greatly assisted by Mr. John G. Morse of Ripley Hill Road, Concord, Mass., son of E. S. Morse. He has sent me much information, has answered many questions. Mr. L. W. Jenkins, Assistant Director of the Peabody Museum, and Mr. A. P. Morse, Curator of Natural History, have also been very helpful. I have also had information from Mrs. Mary B. Clarke, Professor Morse's sister, who lives at Gorham, Maine. Mr. F. W. Coburn, of Lowell, Mass., who wrote the admirable account of E. S. Morse in the Dictionary of American Biography, has also written me a delightful and very informative letter. And Miss Mabel Colcord, the very able librarian of the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture at Washington, has been of great assistance in bringing together for my reading, literally scores of books and publications that have been used in preparing this account. I am also indebted to Miss Emma Stephenson of the Yale University Library for several references.

BIBLIOGRAPHY

Mr. A. P. Morse formerly of Wellesley College but now of the Peabody Museum, has prepared a full manuscript list of E. S. Morse's published writings which is now deposited at the Peabody Museum at Salem. It contains 558 titles. But his list includes the titles of many newspaper articles on many fugitive subjects, as well as the titles of books and articles on Japanese art. The list that follows contains the titles of only scientific articles, mainly published before Morse went to Japan (124 titles in all). The full bibliography may be consulted at the Peabody Museum.—L. O. H.

1857

Helix asteriscus, Morse (description of). (Communication read Feb. 4, 1857.) Proc. Boston S. N. H., vol. 6, p. 128.

1859

Helix milium Morse (description of). (Read at meeting of Boston S. N. H., Feb. 16. Publ. prob. 1861.) Proc. Boston S. N. H., vol. 7, pp 28-29.

1862

On the relative positions in nature to be assigned to the Articulata and Mollusca respectively. (Title only. Read Jan. 6, 1862.) Proc. Portland S. N. H., vol. 1, pt. 1, p. 37.

The Haemal and Neural regions of Brachiopoda. (Commun. read by S. H. Scudder at meeting of Boston S. N. H., April 16, 1862). Proc. Boston S. N. H., vol. 9, pp. 57-60.

General Homologies of Mollusca,—Report of remarks on, particularly Cephalopods. Proc. Portland S. N. H., vol. 1, pt. 2, p. 98. (Date on t. p. 1869,—see next no.)

Excavations at Goose Id., Me., and occurrence of rare Helices beneath Indian deposits,—Report of account of, at meeting of Portland S. N. H., Nov. 17, 1862. Proc. Portland S. N. H., vol. 1, pt. 2, p. 98. (Date on t. p. 1869; on p. 60 of Journ. Portland S. N. H. date of pub. given as 1862. Prob. referred to in No. 162, Shell Mounds of Omori, p. 24, note, as 1863.)

Report of description and illustration of the anatomy of *Margaritana arcuata* before meeting of Portland S. N. H., Jan. 19, 1863. Proc. Portland S. N. H., vol. 1, pt. 2, p. 104.

1864

Contributions to natural history. Helix arborea. Northern Monthly, vol. 1, no. 2, April, pp. 118-120, 3 fig.

Contributions to natural history. Variability of Species. Northern Monthly, vol. 1, no. 4, June, pp. 267-270.

Synopsis of the fluviatile and terrestrial Mollusca of the State of Maine.—(Folio sheet, 4 pp., 3 printed.)
Pub. by Author, Portland, Me.

Observations on the terrestrial Pulmonifera of Maine, including a catalogue of all the species of terrestrial and fluviatile Mollusca known to inhabit the State. Journ. Portland S. N. H., vol. 1, no. 1, pp. 1-63, pl. 1-10 (26 figs. on pls. 1 & 2; 104 in text and on pls. 3-10.) Portland, Me. 1864. Stephen Berry, Printer.

1865

A classification of Mollusca, based on the "Principle of Cephalization". (A communication to the Essex Inst., June 19, 1865.) Proc. Essex Inst., vol. 4 (1864-5, pub. 1866), pp. 162-180, 2 fig. in text, 1 pl. Also, sep., "Pub. June, 1865." Also, Am. J. Sc. & Arts, 2nd ser., vol. 42, pp. 19-33, 2 fig. in text, 1 pl., pub. 1866.

Descriptions of new species of Pupadae. (Read Nov. 20, 1865.) Ann. Lyc. N. H. N. Y., vol. 8, pp. 207-212. 8 fig. Also, Sep., pp. 1-6.

1867

Report of remarks on Cephalopods, citing Victor Hugo's Devil-fish, before Essex Inst., May 4, 1867. Am. Nat., vol. 1, Feb. 1868, p. 680.

A New Insect Box. Am. Nat., vol. 1, May 1867, p. 156, 1 fig.

Something about jelly-fishes. Am. Nat., vol. 1, July 1867, pp. 244-253, 1 pl.

The land snails of New England. Am. Nat., vol. 1, Mar. 1867, pp. 5-16, 1 pl., 13 fig. Am. Nat., vol. 1, Apr. 1867, pp. 95-100, 7 fig. Am. Nat., vol. 1, May 1867, pp. 150-151, 8 fig. Am. Nat., vol. 1, June 1867, pp. 186-188, 3 fig. Am. Nat., vol 1. Aug. 1867, pp. 313-315, 7 fig. Am. Nat., vol. 1, Oct. 1867, pp. 411-414, 6 fig. Am. Nat., vol. 1, Dec. 1867, pp. 541-547, 33 fig. Am. Nat., vol. 1, Jan. 1868, pp. 606-609, 11 fig. Am. Nat., vol. 1, Feb. 1868, pp. 666-672, 28 fig.

Preparation of snails' tongues as microscopical objects. (Note under "Correspondence".) Am. Nat., vol. 1, p. 326.

Report of remarks on the principle of cephalization as applied to the classification of the mollusca, at meeting of Sept. 18, 1867. Proc. Boston S. N. H., vol. 11, p. 287.

Abstract of remarks on evidences of great antiquity in the shell-heaps at Goose Id., Me., at meeting of Oct. 2, 1867. (See No. 15.) Proc. Boston S. N. H., vol. 11, pp. 301-302.

1868

A stroll by the sea-side. Am. Nat., vol. 2, July 1868, pp. 236-251, 1 pl. (14 fig.), 1 t. f.

Report of remarks on the growth of a new entomostracous crustacean, *Limnadia americana*. Proc. Boston S. N. H., vol. 11, p. 404.

1869

Report of general curator. Proc. Portland S. N. H., vol. 1, pp. 199-201. Also, in extract entitled "History and Condition of the Portland S. N. H. from 1866-1869", same pagination.

On the land-slides in the vicinity of Portland, Maine. (Read at meeting of Jan. 6, 1869.) Proc. Boston S. N. H., Jan. 20, 1869, vol. 12, pp. 235-244, 3 fig., map.

Abstract of answer to criticism in Zoological Record relative to popular articles on land snails of New England and their classification. (See No. 49.) Proc. Boston S. N. H., vol. 12, pp. 318-319. Also, sep., 1 p. In List of papers—No. 147,—this is No. 10.

Report on the Mollusca (including Appendix) and Report on the Radiata. 1st Ann. Rept. Trust. Peab. Ac. Sc. (Jan. 1869), pp. 74-77. (In Appendix describes "*Cyclocardia Novangliae* Morse (nov. sp.)", pp. 76-77, 2 fig.) Also, reprint.

On the early stages of Brachiopods. ("Extract selected and adapted from Boston Daily Advertiser.") Can. Nat., new ser., vol. 4, pp. 321-322. Am. Nat., vol. 3, pp. 385-386, 7 fig. (See No. 66.) Also, sep., 2 pp., 7 fig.

Evidences of high antiquity in the Kjoekkenmoedden deposits of New England—(Report of remarks on.) ("Extract selected and adapted from Boston Daily Advertiser.") Can. Nat., new ser., vol. 4, p. 329. See No. 52 this list.

Review of "Outlines of Comparative Anatomy and Medical Zoology" by Harrison Allen. Am. Nat., vol. 2, Feb. 1869, pp. 654-655.

Salt and fresh-water clams. Am. Nat., vol. 3, Mar. 1869, pp. 21-27, 1 pl. with 8 fig.

Shell dredging. Am. Nat., vol. 3, July 1869, pp. 269-274, 1 pl. with 33 fig.

On the early stages of Brachiopods. Am. Nat., vol. 3, Sept. 1869, pp. 385-386, 7 fig. (See No. 61.) Am. J. Sc. & Arts, 2nd ser., vol. 49, pp. 103-104, 7 fig. See also No. 75.

Our common fresh-water shells. (First article.) Am. Nat., vol. 3, Dec. 1869, pp. 530-535, 5 fig. in text, 1 pl. with 22 fig. (See No. 77, a second article.)

Vertigo, Generic characters and native species of (Remarks on). (Title only. At regular meeting, Feb. 15, 1869.) Bull. Essex Inst., vol. 1, p. 32.

Local mollusks and development of animals as illustrated by common frog (Remarks on). (At field meeting, June 10.) Bull. Essex Inst., vol. 1, p. 90.

Report of remarks "principally on the Glacier system, as illustrated by the various boulders found in the vicinity, etc." (At field meeting, July 18.) Bull. Essex Inst., vol. 1, p. 99.

Report of remarks on the manufacture of paper. (At field meeting, Aug. 5.) Bull. Essex Inst., vol. 1, p. 102.

On the early stages of Terebratulina septentrionalis (Couthouy). (Read Oct. 20, 1869.) Mem. Boston S. N. H., vol. 2, pt. 1, no. 2, pp. 29-39, pls. 1 & 2 with 58 fig. Also, Ann. & Mag. N. H., vol. 8, 4th ser., (1871), pp. 414-427, pls. 15 & 16 with 35 fig.

1870

On the early stages of Brachiopods. Am. J. Sc. & Arts, 2nd ser., vol. 49, pp. 103-104, 7 figs. (from Am. Nat., Sept. 1869). See No. 66.

Our common fresh-water shells. (Second article.) See No. 67. Am. Nat., vol. 3, pp. 648-651, 6 fig. in text, 1 pl. with 27 fig.

Position of the Brachiopoda in the animal kingdom. Am. Nat., vol. 4, July 1870, pp. 314-316, 3 fig. Also, sep., 3 pp., 3 fig. (not quite identical with preceding). Also, abstr., 3rd person, Mo. Mic. Journ., vol. 4, pp.162-164.

(Abstract of remarks) "On the early stages of Discina." Proc. Am. Assn. Adv. Sc., vol. 19 (1870), p. 270.

(Remarks) "On the organization of Lingula and Discina." Proc. Am. Assn. Adv. Sc., vol. 19 (1870), pp. 271-272.

The Brachiopoda, a Division of Annelida. Proc. Am. Assn. Adv. Sc., vol. 19 (1870), pp. 272-276. Am. Journ. Sc. & Arts, 2nd ser., vol. 50, July, pp. 100-104, 3 fig. Also, sep. from above, 5 pp., 3 fig. Also, very short abstr. of verbal comm. to Boston S. N. H. in Proc. Boston S. N. H., vol. 13, p. 416. Also, Ann. & Mag. N. H., vol. 6, 4th ser., pp. 267-270, 3 fig., from Am. Journ. Sc. & Arts, July.

Report of remarks on grasshoppers and various natural history topics. (At field meeting, Aug. 4.) Bull. Essex Inst., vol. 2, (1870), p. 120.

Report of remarks on the structure and habits of Phascolosoma. (Communicated to the meeting of Nov. 16, 1870.) Proc. Boston S. N. H., vol. 14, p. 61.

1871

A reply to Mr. Dall's criticism on the Brachiopods as a division of the Annelids. Am. J. Sc. & Arts, vol. 1, 3rd ser., Feb. (1871), pp. 136-138.

Report of remarks on the relationships of the Tunicates. Proc. Boston S. N. H., vol. 14, p. 137.

On the adaptive coloration of Mollusca. (Read at meeting of Apr. 5, 1871.) Proc. Boston S. N. H., vol. 14, pp. 141-145.

Are the Brachiopods Annelida? (Abstr., largely quoted.) Mo. Mic. Journ., vol. 5 (1871), pp. 135-136.

Abstract of remarks on the carpal and tarsal bones of birds. (By E. S. M.?) Am. Nat., vol. 5 (1871), pp. 524-525. Also, Proc. Am. Assn. Adv. Sc., vol.. 20 (1871), pp. 277-278.

On the relations of Anomia. Proc. Boston S. N. H., vol. 14, pp. 150-153, 6 fig. Also, Am. Nat., vol. 5 (Sept. 1871), pp. 533-535. Also, sep., pp. 1-4, Boston, A. A. Kingman, printer.

Notes on the early stages of an Ascidian, (*Cynthia pyriformis*, Rathke). (Read at meeting of Oct. 18, 1871.) Proc. Boston S. N. H., vol. 14, pp. 351-355, 1 pl. with 6 fig.

Remarks on the bones of the carpus and tarsus in birds and reptiles. Proc. Boston S. N. H., vol. 14, p. 391.

Report of observations on a "Spittle Insect." (At meeting of Nov. 15, 1871.) Proc. Boston S. N. H., vol. 14, p. 391.

1872

On the oviducts and embryology of Terebratulina. Am. J. Sc. & Arts, 3rd ser., vol. 4, Oct. 1872, pp. 262-263, 1 pl. with 17 fig. Also, abstr. of above art. in Mo. Mic. Journ., vol. 8 (1872), pp. 274-275. Also, Proc. Am. Assn. Adv. Sc., vol. 21 (1872), pp. 222-225, 1 pl.

Report of remarks on the Spittle Insect. Bull. Essex Inst., vol. 4. (1872), pp. 107-108.

1873

On the systematic position of the Brachiopoda. (Review: Am. Nat., vol. 8, pp. 43-53, 39 fig.) Proc. Boston S. N. H., vol. 15 (Mar. 19, 1873, pp. 315-372, 1 pl. with 10 fig.—fig. 42 and 6 in text). Also, sep., Boston, A. A. Kingman, printer, pp. 1-60, 1 pl. (10 figs.) 48 fig. in text, 4 fig. on covers.

The evolution theory. (Reprint of remarks by E. S. M. and others at Portland meeting of Am. Assn. Adv. Sc., from N. Y. Tribune.) Can. Nat., vol. 7, pp. 153-155.

On the embryology of Terebratulina. (Abstr., 1st person.) Proc. Am. Assn. Adv. Sc., vol. 22, sect. B, pp. 308-310.

On the Genitalia of Brachiopoda. (Abstr., 1st person.) Proc. Am. Assn. Adv. Sc., vol. 22, pt. 2, sect. B, pp. 310-311. (This is abstr. of paper in Proc. Boston S. N. H., vol. 15, pp. 315-372).

Relation of Dentalium. (Title only.) Proc. Am. Assn. Adv. Sc., vol. 22, pt. 2, sect. B, p. 408. Also mentioned, vol. 23, pt. 2, sect. B, p. 147.

Embryology of Terebratulina. Mem. Boston S. N. H., vol. 2, pt. 3, No. 1, pp. 249-264, 2 pl., 105 fig.

1874

The fertilization of flowers (and on carnivorous plants.) Bull. Essex Inst., vol. 6 (1874), No. 7 (July), pp. 109-111.

Report of remarks on glacial phenomena and use of striae as guides by Indians. Bull. Essex Inst., vol. 6, (1874), p. 157.

Report of remarks on turtles, embryology, and evolution. (At field meeting of Essex Inst., at Concord, July 27. E. S. M. "announced himself a believer in the theory of Darwin.") Bull. Essex Inst., vol. 7, pp. 137-138.

First Book of Zoology. Pp. 14, 190, many ill. from drawings by the author. N. Y., D. Appleton & Co. (Later, by Amer. Book Co.) 2nd ed., 1877. In German ("Anfangsgrunde der allgemeinen Zoologie"), 1877, Stuttgart; 2nd ed. 1881, Berlin. Also in Japanese.

1876

On a diminutive form of Buccinum undatum, Male:—Case of natural selection. Separate, title page and pp. 2-4, issued 1876,—from Proc. Boston S. N. H., vol. 18, pp. 284-287, 4 figs.

What American zoologists have done for evolution. (Address, Am. Assn. Adv. Sc., Buffalo, Aug. 1876.) Separate, pp. 1-42, Salem, Mass., 1876. Proc. Am. Assn. Adv. Sc., vol. 25, sect. B, pp. 137-176 (1876), pub. 1877. Also, Pop. Sc. Mo., Nov. pp. 1-16; Dec. 181-198 (1876).

Report of remarks on Drosera, and on noises produced by insects. Bull. Essex Inst., vol. 8 (1876), p. 69.

1878

Man's place in nature. (A criticism and protest concerning quotations made from Huxley's work.) Sci. Amer., Apr. 6.

Evidences of cannibalism in a nation before the Ainos in Japan. (Title only. See No. 164.) Proc. Am. Assn. Adv. Sc., vol. 27, for 1878, pt. 2, sect. B, p. 339.

Traces of an early race in Japan. Pop. Sc. Mo., vol. 14 (Jan. 1879), pp. 257-266, 31 figs. Reprint, with cover, same pagination.

Shell mounds of Omori. Mem. Science Dept., Univ. Tokio, Japan, vol. 1, pt. 1, pp. vi, 36, 18 pl., frontisp., small quarto. Includes, pp. 23-36, No. 162. There is also a Japanese ed. (Review in Am. Nat., Jan. 1880, pp. 43-44.)

A comparison between the ancient and modern Molluscan fauna of Omori. Mem. Sc. Dept. Univ. Tokio, vol. 1, pt. 1, pp. 23-36, 1 pl. Reprint, pp. 1-16, 1 pl.

Note on the extension of the coiled arms in Rhynchonella. (Commun. dated Tokio, Japan, Nov. 26 1878.) Am. J. Sc. & Arts, vol. 17, 3rd ser., p. 257. Reprint, leaded to 1 p., 1 fig., dated Mar. 1869. (Sic!)

1880

The Omori shell mounds. (E. S. M.'s letter to Chas. Darwin regarding review of E. S. M.'s memoir by Fred V. Dickins, and letter to editor of "Nature" by Darwin.) Nature, London, April 15, pp. 561-562. Reprint, Salem, Mass., 1880, together with "Some recent publications on Japanese archaeology (No. 180) and notice from 'Japan Mail.'"

Report of remarks on mudwasp, barnswallows, and the Japanese people. Bull. Essex Inst., vol. 12 (1880), p. 136.

Report of remarks on the Japanese language, glacial phenomena, and mollusca. Bull. Essex Inst., vol. 12 (1880), pp. 169-170.

The gradual dispersion of certain mollusks in New England. Bull. Essex Inst., vol. 12 (1880), pp. 171-176, map, 1 fig. Also, sep., 8 pp. map, 1 fig.

On the identity of the ascending process of the astragalus in birds with the intermedium. Anniv. Mem. Boston S. N. H. (1880), pp. 1-10, 1 pl. with 12 figs., 12 figs. in text. Qto. (Pub. 1881.)

1881

Prehistoric man in America. North Am. Review, vol. 132, June, pp. 602-616.

Worked shells in New England shell-heaps. (Abstr. prepared or approved by E. S. M.) Proc. Am. Assn. Adv. Sc., vol. 30, Aug. 1881, pp. 343-4. Am. Nat., Dec. 1881, p. 1016.

Changes in Mya and Lunatia since the deposition of the New England shell-heaps. (Abstr. prep. or appr. by E. S. M.) Proc. Am. Assn. Adv. Sc., vol. 30, Aug. 1881, p. 345. Am. Nat., Dec. 1881, p. 1015.

1882

Wild animals as man's associates. Pop. Sc. Mo., Feb. 1882, pp. 528-531.

1883

Mya arenaria: its changes in Pliocene and prehistoric times. (Abstr.) Proc. Am. Assn. Adv. Sc., vol. 32, pp. 361-362.

1884

Notes on the condition of zoology, fifty years ago and today: in connection with the growth of the Essex Institute. Bull. Essex Inst., vol. 16 (1884), pp. 113-121. Sep., pp. 1-9, title page and cover.

Man in the Tertiaries. (Address delivered before the section of Anthropology of the Am. Assn. Adv. Sc., Sept. 4, 1884.) Am. Nat., Oct. 1884, pp. 1001-1012. Sep., Salem Press, 1884, pp. 1-15. Proc. Am. Assn. Adv. Sc., vol. 33 (1884), pp. 579-591.

1887

Address: "What American zoologists have done for evolution," continued, of retiring president of American Association for the Advancement of Science, at New York meeting, August 1887. Sep., Salem Press, cover, title page, pp. 1-43, 1887. Proc. Am. Assn. Adv. of Sc., vol. 36 (1887), pp. 1-43.

1888

On ancient arrows and a new method of arrow release. (Title only,—paper read at Cleveland meeting.) Proc. Am. Assn. Adv. Sc., vol. 37, p. 329.

1895

Review of "Textbook of Invertebrate Morphology," by McMurrich. Pop. Sc. Mo., vol. 47, July 1895, pp. 413-414.

1896

Review of "Dispersal of Shells," by Kew. Science, Feb. 28, p. 324.

Review of "Cambridge Natural History, vol. V, Peripatus, etc." Pop. Sc. Mo., vol. 49, May 1896, p. 133.

1897

Review of "Round the Year: A Series of Short Nature-Studies," by L. C. Miall. Science, Feb. 5, pp. 227-228.

Review of "Cambridge Natural History, Vol. VI, Insects," part II. Pop. Sc. Mo., vol. 50, Mar. 1897, p. 710.

Acquired immunity from insect stings. Nature (Letters to the Editor), Apr. 8, p. 533.

1898

Review of "History of Mankind," vols. I and II, by Ratzel. Pop. Sc. Mo., Apr. 1898, pp. 846-849.

Was middle America peopled from Asia? Pop. Sc. Mo., vol. 54, Nov. 1898, pp. 1-15. Reprint, cover, title page, pp. 3-16.

Henry Mason Brooks. A Memoir. Hist. Coll. Essex Inst., Salem, vol. 34, pp. 219-231, portr. Reprint, pp. 1-15, portrait.

1899

Pre-Columbian musical instruments in America. Pop. Sc. Mo., vol. 54, Mar. 1899, pp. 712-714, 3 figs.

The Damariscotta shell heaps. (A correction of statements by H. W. Brown attributed to E. S. M. in Feb. No., p. 34.) Pop. Sc. Mo., vol. 33, Apr. 1899, p. 95.

Review of "The Last Link," by E. Haeckel. Pop. Sc. Mo., vol. 55, May 1899, pp. 126-127.

Review of "The Foundations of Zoology", by W. K. Brooks. Pop. Sc. Mo., June 1899, pp. 270-272.

1900

A bubble-blowing insect. Pop. Sc. Mo., vol. 57, May 1900, pp. 23-29, 6 figs.

1901

Observations on living Brachiopoda. (Read at Boston, Nov. 20, 1901.) Mem. Boston S. N. H., vol. 5, no. 8, pp. 313-386, 23 pl. (1 col.).

1902

Address on Alpheus Hyatt, at memorial meeting, Boston Society of Natural History, Feb. 5, 1902. Proc. Boston S. N. H., vol. 30, no. 4, pp. 415-420.

Same, entitled "A Young Naturalist, Alpheus Hyatt at Cambridge." Boston Transcript, Apr. 30.

Pholas truncata in Salem Harbor. Nautilus, vol. 16, no. 1, p. 8.

1907

Eyes of Helicodiscus lineatus. Nautilus, vol. 21, no. 7, Nov. 1907, p. 73.

Jean Louis Rudolph Agassiz. Pop. Sc. Mo., vol. 71, Dec. 1907, pp. 542-549. Also, sep., same pagination.

1908

A new method of mounting ethnological objects. Proc. Am. Assn. Mus., vol. 1, pp. 60-61, 2 pl.

1909

Shells new to the New England fauna. Nautilus, vol. 22, Jan. 1909, p. 95.

1910

An early stage of Acmaea. Proc. Boston S. N. H., vol. 34, no. 8, pp. 313-323, 8 figs.

1912

Biographical Memoir of Charles Otis Whitman. 1842-1910. Biog. Mem. Nat. Ac. Sc., vol. 7, pp. 269-288, portrait.

1916

Fireflies flashing in unison. Science, Feb. 4, pp. 169-170. Reprint.

Frederick Ward Putnam. 1839-1915. An Appreciation. (Read at annual meeting, Trustees Peabody Museum, Mar. 1916.) Hist. Coll. Essex Inst., vol. 52, no. 3, July 1916, pp. 193-196, portr. Reprint, Essex Inst., pp. 1-8, portr. frontisp., cover.

Fireflies flashing in unison. Science, Sept. 15, pp. 387-388.

1918

Fireflies flashing in unison. Science, July 26, pp. 92-93. Reprint, pp. 1-4.

1919

New forms of Caecum in New England. Nautilus, vol. 32, no. 3, Jan. 1919, pp. 73-77, 1 pl. with 8 figs. Also, separate, pp. 1-5 and pl.

A European mollusk, Helcion pellucidum, never before recorded in America. Nautilus, vol. 32, no. 3, Jan. 1919, pp. 77-78.

Observations on living Lamellibranchs of New England. (Title only.) Proc. Am. Arts & Sc., vol. 54, p. 392. (Probably the same as the following item.)

Observations on living Lamellibranchs of New England. Proc. Boston S. N. H., vol. 35, no. 5, pp. 139-196, 48 figs. with 143 sketches.

1920

Biographical Memoir of Charles Sedgwick Minot. 1852-1914. Biog. Mem. Nat. Ac. Sc., Apr. 1920, vol. 9, pp. 263-285, portrait.

On the occurrence of Pyramidula rupestris in Maine. Nautilus, vol. 34, Oct. 1920, pp. 58-59, 3 figs. (Proposes new varietal name, p. 59.)

Imitative construction of birds' nests. Bull. Essex Orn. Club, Dec. 1920, pp. 23-25.

1921

Observations on living Gastropods of New England. (Includes appendix on nomenclature.) Peab. Mus., Salem, Mass. Pp. 1-29, pl. 1-9, with 119 sketches.

1922

An abnormal shell of Mya arenaria. Nautilus, vol. 36, July 1922, pp. 28-30, 2 drawings.

1924

The synchronous flashing of fireflies. Science, Feb. 15, pp. 163-164.

Joseph Leidy's Influence on Science. Sci. Mo., vol. 18, Apr. 1924, pp. 422-427. Reprint, same pagination. Also, *same,* in "The Joseph Leidy Commemorative Meeting held in Philadelphia, Dec. 6, 1923," pp. 22-27, under title of "General Estimates of Leidy's Influence upon Scientific Thought."

1925

Shell-mounds and changes in the shells composing them. Sci. Mo., Oct. 1925, vol. 21, pp. 429-440, 7 figs.

George P. Merrill

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVII—SECOND MEMOIR

BIOGRAPHICAL MEMOIR

OF

GEORGE PERKINS MERRILL

1854–1929

BY

WALDEMAR LINDGREN

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1935

GEORGE PERKINS MERRILL

1854–1929

BY WALDEMAR LINDGREN

The sources for the preparation of this memorial are first, an autobiography of Merrill prepared in 1924 and which was submitted to me by the president of the National Academy of Sciences; second, a biography by his friend, Charles Schuchert, published by the Geological Society of America;[1] third, a personal acquaintance with Doctor Merrill dating back to 1890 when I first met him in Washington and continuing at intervals from 1912 to 1929 after my transfer to Boston. To Mrs. Merrill I am greatly indebted for much information obtained in conversation. Miss M. Moodey, who for many years was Doctor Merrill's secretary, has also kindly furnished notes regarding his work.

George Perkins Merrill was born May 31, 1854, at Auburn, Maine. After his undergraduate studies in Maine he was appointed to the geological department of the U. S. National Museum in 1881, and soon became its Curator, remaining an officer of the Museum for nearly 50 years and until his death. He suddenly passed away at Auburn, August 15, 1929, where he had usually spent a short time each summer.

Merrill was married in 1883 to Sarah Farrington of Portland, Maine. In 1892 she fell seriously ill, and died in 1894, leaving four children, one son and three daughters. In 1900 Merrill married Katherine L. Yancey of Virginia, who survives him and by whom he had one daughter.

Merrill was a descendant of an old New England family, one of his ancestors, Nathaniel Merrill, having settled in Old Newberry, Massachusetts, in 1638. It is said that Nathaniel Merrill was originally one of the Huguenots who were driven out of France on St. Bartholomew's day, the name being De Merles, later changed to Merrill. His father, Lucius Merrill, was a carpenter and cabinet maker; his mother Anne (Jones)

[1] Bull. Geol. Soc. America, 42, pp. 95-122, 1931.

Merrill was a daughter of a clergyman long settled in Minot, Maine. The family was large and it became necessary that the young man should do his part toward its support. So it happened that he soon became independent, doing chores for the family and neighbors; later, from the age of eighteen to twenty-one, working in the shoe factories. As he states, his early education was "necessarily scrappy," but with indomitable courage he worked his way, so that in 1876 he entered the University of Maine, at Orono, there supporting himself. In 1879 he obtained the B.S. degree in chemistry. In 1883 he was given the degree of M.S., and in 1889, Ph.D. from the same institution. In 1917 he received the honorary degree of Sc. D. from George Washington University. In 1922 he was elected a member of the National Academy of Sciences, and the same year he was awarded the J. Lawrence Smith gold medal of the Academy for his researches on meteorites. He was a member of many scientific societies, particularly the American Philosophical Society, the Academy of Natural Sciences of Philadelphia, the Washington Academy of Sciences (president 1906-1907), the Geological Society of America (vice-president 1920), the Maryland Academy of Sciences and many other learned organizations.

His earliest work was in chemistry as assistant at the Wesleyan University, Middletown, Connecticut. In the winter of 1880-1881 he was connected with the fisheries census in Washington, and in the following year, through the support of G. Browne Goode, then in charge of the U. S. National Museum, he was appointed aid to George W. Hawes, the petrographer in that institution. These two men undoubtedly influenced his choice to take up the study of mineralogy and geology. He already strongly inclined toward these branches of the natural sciences, evidently in part through the influence of his grandfather at Minot. Under Hawes he took part in the work of the Tenth Census, in which many young geologists gathered their first laurels studying collections of rocks and ores. Under Hawes he also began petrographic studies and learned the preparation of thin sections of rocks. He was thus one of the earliest petrographers of this country, later working with George H.

Williams at Johns Hopkins University. Merrill was appointed curator of the geological department in the museum and in 1897 head curator of the department, a position which he held until his death.

One's first impression on meeting Merrill was that of a reserved and austere man, about 5 feet 10 inches in height, and of sturdy, erect build, with sandy hair and short van Dyke beard, and remarkably keen blue eyes. I always thought he changed but little with age. Always occupied, reading and studying, and arranging or planning his great collections in mineralogy and geology, he gave the impression of being interested only in his duties and researches. But underneath this first impression he revealed to his friends a mind rich in knowledge and appreciation of art, literature and music, rich also in humor and in apt quotation.

In his geological work he was primarily an investigator and a research man. He had little inclination to advance and discuss speculative theories, much preferring to stay close to the facts. Looking back on his life's work I have been amazed at its quality and quantity in so many different branches. His life was a busy one indeed, and in spite of ill health during part of his later years, he made an imprint on the history of geology which time will not easily efface.

Though Merrill was not primarily a field geologist, his experience in the field was quite extensive. He assisted Dr. Peale in 1887 and 1889 in the mapping of the classical "Three Forks Folio, Montana." He attended the Geological Congress of 1897 in St. Petersburg, and had opportunity of visiting much of Russia and the Ural Mountains and to examine the great museums of Europe. In 1905 he visited Lower California to investigate certain onyx deposits, and in connection with his studies of building stones and meteorites he visited a large number of localities of exceptional interest in the United States. Merrill's bibliography contains a great number of papers on individual minerals and rocks, aside from his principal fields of investigation. Of particular interest is an article on "Gold in Granite," the specimen from Sonora, Mexico, apparently containing gold of direct magmatic origin (Bibliography, 1896).

In order to appreciate fully the extent of his life's work it should be stated that his bibliography contains some 200 titles, many of his papers being of extensive dimensions. He wrote 47 annual reports of his department, and he was a contributor to at least six dictionaries and encyclopedias. From 1893 to 1915 he held the chair of mineralogy and geology at the (present) George Washington University, lecturing there several hours a week after official office hours.

It is appropriate to consider Merrill's scientific work under the following heads, bearing in mind, as Dr. Schuchert points out, that in three or four of these branches he may be considered a pioneer, at least in this country:

As organizer of the Department of Geology in the U. S. National Museum.

As an investigator of the quality and petrography of building stones.

As a student of the processes of weathering.

As a writer of practically the first book on non-metallic deposits.

As an authority on the petrography of meteorites.

As an historian of North American geology.

ADMINISTRATOR AND COLLECTOR

To have organized, arranged or supervised the arrangement of the collection in geology and mineralogy of the U. S. National Museum might well be considered the work of a lifetime. Anyone conversant with the administrative duties of such a museum will realize this. At the present time this Museum is inferior to none; probably it is among the two or three of the very best in the world.

In 1883 Merrill reports having in charge about 12,500 specimens. Starting thus single-handed in 1880 this section had grown in 1929 to a staff of nineteen curators or associates. It contained 93,044 specimens in the geological collection; 132,279 specimens in the section of mineralogy and petrography; 1,765,-600 specimens in the section of stratigraphy or invertebrate paleontology; and 24,497 specimens in the section of vertebrate paleontology; a total of 2,015,420 specimens. The arrangement

of this collection is wonderfully effective, particularly in the mineralogical and economic branches. The successful assembly and arrangement of these enormous collections testify to the great administrative ability of Merrill.

Several publications in the Reports of the Smithsonian Institution and later in the Reports of the U. S. National Museum, illustrate and describe these collections, particularly a book issued separately under the title of "Illustrated Handbook, the Department of Geology of the U. S. National Museum," 1923.

INVESTIGATOR OF BUILDING STONES

The examination of rocks by means of the petrographic microscope began to be developed in the United States about the time Merrill was appointed assistant to Dr. Hawes, who was one of the pioneers in this branch. About the same time Rosenbusch's handbook became generally known, as well as Zirkel's classical investigation of the rocks collected by the Fortieth Parallel Survey. Hawes was appointed special agent of the Tenth Census in charge of building stones, and a very large collection had been brought together from all parts of the United States. After the untimely death of Hawes in 1882 Merrill was appointed in charge of the lithological investigation in this branch, and all this led him directly to the taking up of microscopic petrography. He soon became an expert in this new branch of science. Hawes' plan called not only for an investigation of the industry but also for the petrographic character of the building stones, and the influence of this on the selection of proper material, and on the durability of the stones. One of the first of his duties was the preparation of thin sections of this great collection, and the result of his work was published in Volume 10 of the Tenth Census (1884). In 1889 he brought together the information in a Museum handbook of the building stone collection. It was later (1891) published in revised form as a book of 500 pages entitled: "Stones for Building and Decoration," which passed through three editions. This established his reputation as a pioneer and an authority on building stones of the United States. Thereafter he was frequently consulted in the selection of proper materials

for important buildings and monuments. One of his tasks was the selection of the stone for the Lincoln Memorial.

INVESTIGATOR OF PROCESSES OF WEATHERING

Undoubtedly, the study of building stones led directly to the study of the changes they undergo near the surface. The disintegration of the granitic rocks in the District of Columbia so well exposed near the Zoological Park surely attracted his attention at an early date. Such processes of weathering had been noted and described before, particularly by Roth in Germany, but Merrill began a detailed study to trace the exact chemical and mechanical processes. He collected his specimens and separated and analysed them to ascertain just what amounts of the various minerals had been decomposed, what substances had been leached, and what had been added. By the assumption of constant alumina he succeeded in calculating the almost exact amount of additions and losses.

Merrill made similar careful examinations of the Medford diabase dike (Massachusetts), the gneiss of Virginia, and weathered rocks from many other places, which served as models for later work. In 1896 he published a notable paper in the *Journal of Geology* on the "Principles of Rock Weathering." The next year there appeared his book on "Rocks, Rock Weathering and Soils" (pp. 411). A second edition came out in 1906. This book, which has been most useful and illuminating to hundreds of geologists, firmly established Merrill's reputation as a pioneer and an authority on the processes of weathering.

AUTHORITY ON THE NON-METALLIC MINERALS

In the bibliography of Merrill one may find a considerable number of papers on the non-metallic minerals, referring by this name rather to the uses than to the chemical composition. In 1901 one finds "A Guide to the Study of the Collections in the Section of Applied Geology," published in the annual report of the Museum. Many descriptions of the metallic ores had previously been written, but the minerals used for non-metallic

purposes had been greatly neglected. In 1904 Merrill wrote a book (pp. 415) on "The Non-Metallic Minerals, Their Occurrence and Uses," which filled a long felt want of economic geologists. A second enlarged edition was issued in 1910. The writer can gratefully testify to the excellence of this book, in which for the first time the rarer as well as the common minerals were described, with abundant notes on their distribution and uses. Here again we find Merrill a pioneer.

THE FOREMOST AMERICAN AUTHORITY ON METEORITES

Since 1888, when he published his first study of meteorites, Merrill contributed nearly 80 papers on this subject, mostly describing American occurrences, and his interest in this subject continued until his death. His last paper (Bull. 149, U. S. Nat. Museum), issued after his death, was of a comprehensive nature, entitled: "Composition and Structure of Meteorites." He was without doubt the foremost authority on this subject in our country.

Since the days of Berzelius meteorites have, of course, been studied by a large number of authors in Europe, such as Sorby, Haidinger, Tschermak, Cohen, and Brezina. It is worthy of note that C. U. Shepard was the earliest student of meteorites in America; he published 30 papers on meteorites from 1829 to 1886. However, it was not until the methods of microscopical petrography were developed that real progress was made. The National Museum under Merrill's direction, accumulated a collection of these wanderers in space, which is now one of the great collections in the world. Merrill's study was largely directed to the stony meteorites and their peculiar textures, mostly made up of olivine and pyroxene. He discussed not only their composition but also their origin, holding that "the earth today in its course is but passing through and receiving from space a deposit of materials representing one and the same original body, and that body one of an exceeding basic nature, not necessarily resembling in percentage composition the materials which may have reached us during past and earlier

stages of earth history." And in another place: "We are bound, it seems to me, to regard the meteorites as world matter. If so regarded, we are confronted at once with the general basic nature of the original magma from which they were derived."

A new calcium-sodium phosphate, described from an Indian meteorite, has been named Merrillite. Merrill's investigations were supported by aid from the National Academy of Sciences and, as noted above, he received in 1922 the J. Lawrence Smith gold medal for his work on meteorites.

In the summer of 1908 Merrill was detailed by C. D. Walcott to make a study of the so-called Coon Butte, or Canyon Diablo "Meteor Crater" of eastern Arizona. After a careful investigation he concluded that the phenomena of this depression and the meteorites scattered in the vicinity pointed clearly to the impact of a large meteorite that is believed to be buried in the rocks below the bottom of the "crater." Later work has strongly supported Merrill's conclusions, which at first were not universally accepted. At least 20 tons of meteoric fragments have been gathered over several square miles of the ground around the "crater," their individual weights range up to 1800 pounds. A full description by Merrill of this remarkable occurrence was published in the Smithsonian Miscellaneous Collections, Vol. 50, 1908.

HISTORIAN OF NORTH AMERICAN GEOLOGY

One might well think that the various activities briefly reviewed would alone be sufficient to fill a lifetime. But, last but not least, it remains to consider Merrill as an historian of North American geology. In his autobiography Merrill explains that during a couple of years in his early connection with the National Museum, he had some time to spare, and that he became interested in the early history of geology in this country; he accumulated biographical notes, portraits and autographed letters of the early workers. It seems strange, but it is true, that few other geologists had thought of such a useful work. Only the merest outlines had been published. Sketches of nearly 200 American geologists were included in his book,

entitled "Contributions to the History of American Geology" (Ann. Rept. U. S. Nat. Museum, for 1904, pp. 189-733). In 1924 the Yale University Press published the entirely rewritten book under the name of "The First One Hundred Years of American Geology" (pp. 733, pls. 36).

"It is a history of the growth of geology in America in all of its physical aspects. Beginning with 1785 it goes to the closing years of the past century—a review of the gradual development of the science in this country through one hundred years.—It is an impressive volume" (Charles Schuchert, in Biography of Merrill).

It is, I should add, a wonderfully useful volume which every geologist in this country should read. It summarizes historical data many of which but for Merrill would have fallen into oblivion.

Another exceedingly useful book was published by Merrill in 1920. Like the former, it assembles a host of important data. It is entitled "Contributions to a History of American State Geological and Natural History Surveys" (Bull. U. S. National Museum, 109, pp. 549; with 37 portrait plates).

Above is presented in briefest outline, the history of Merrill's life and scientific work. I am proud that I was able to count him as my friend. I cannot but help wondering if I have done him justice. Never advertising himself, never proclaiming his discoveries, simply working along steadily and unostentatiously, even his friends might have failed to realize his true stature during his life. I always thought of him as "the man from Maine." In the highest degree he personified the virtues and the merits of that sturdy New England stock from which he descended: quiet, keen of intelligence, persistent, consistent; originating, not following.

He was not what sometimes is called a "general geologist." Early in life he took up mineralogy and petrography, and these studies led him into new fields, scarcely cultivated before. He originated new branches of great scientific and practical importance, and on this work rests securely his fame as one of the leaders of geological science.

BIBLIOGRAPHY

OF

GEORGE P. MERRILL, 1879-1930

Compiled by Margaret W. Moodey

1879

An examination of Dr. Alfredo Cavazzi's method for the separation of nickel from cobalt. Rep. State Coll. Agr. & Mech. Arts, Orono, Me., pp. 30-31.

1882

Microscopic examination and determination of the building stones of Maine. Rep. State Coll. Agr. and Mech. Arts, Orono, Me., pp. 89-100.

Bibliography of writings of Dr. George W. Hawes. Rep. Asst. Director U. S. Nat. Mus., pp. 42-48.

1883

Note on a Potsdam sandstone, or conglomerate, from Berks County, Pa. Proc. U. S. Nat. Mus., vol. 5, pp. 660-661.

On the collection of Maine building stones in the United States National Museum. Proc. U. S. Nat. Mus., vol. 6, pp. 165-183.

Preliminary note on the crystalline schists of the District of Columbia. Proc. U. S. Nat. Mus., vol. 6, pp. 159-161.

Fluidal cavities in quartz grains of sandstones [Fort Ann, New York.] Science, vol. 1, p. 221.

On the black nodules or so-called inclusions in the Maine granites. Proc. U. S. Nat. Mus., vol. 6, pp. 137-141.

1884

Hornblende andesite from the new Bogosloff volcano. Science, vol. 4, p. 524.

[Building stones]. Tenth Census U. S. Report on the building stones of the United States and statistics of the quarry industry for 1880, p. 357, bound as part of vol. 10, but with separate pagination. Washington.

On prochlorite from the District of Columbia. Proc. U. S. Nat. Mus., vol. 7, p. 67.

Preliminary plan for a collection of the building and ornamental stones and rocks of the United States, to be exhibited at the World's Industrial and Cotton Centennial Exposition of 1884-85 at New Orleans. Proc. U. S. Nat. Mus., vol. 7, pp. 573-574. (Also published as Museum Circular No. 25.)

Microscopic structure. Tenth Census U.S. Report on the building stones of the United States and statistics of the quarry industry for 1880, pp. 15-20, plates, bound as part of vol. 10, but with separate pagination. Washington.

1885

Building and ornamental stones of the United States. Pop. Sci. Monthly, vol. 28, pp. 520-532.

On supposed crude jade from Alaska. Science, Mar. 13, p. 209.

On hornblende andesites from the new volcano on Bogosloff Island in Bering Sea. Proc. U. S. Nat. Mus., vol 8, pp. 31-33.

Notes on the mineralogy and lithology of the District of Columbia. Proc. U. S. Nat. Mus., vol. 8, pp. 351-353.

Volcanic dust from southwestern Nebraska. Science, vol. 5, p. 335.

On deposits of volcanic dust and sand in southwestern Nebraska. Proc. U. S. Nat. Mus., vol. 8, pp. 99-100.

1886

On fulgurites. Proc. U. S. Nat. Mus., vol. 9, pp. 83-90.

Notes on the composition of certain "Pliocene sandstones" from Montana and Idaho. Am. Journ. Sci., 3d ser., vol. 32, pp. 199-204.

1887

Fulgurites, or lightning holes. Pop. Sci. Monthly, pp. 529-539, 4 figs.

Common salt; its geology and manufacture. The Chautauquan, vol. 8, no. 2, pp. 82-85.

1888

The literature of geyserite. Am. Geol., vol. 2, pp. 436-437.

What makes it rain? St. Nicholas, vol. 15, no. 6, pp. 403-405, 2 illustrations.

On the selection of building stone. Stone, Dec., pp. 196-197.

Note on the secondary enlargement of augites in a peridotite from Little Deer Isle, Me. Am. Journ. Sci., 3d ser., vol. 35, pp. 488-490.

The salt industry in the United States. Nature, vol. 37, no. 963, Apr. 12, p. 558.

On a new meteorite from the San Emigdio Range, San Bernardino County, California. Am. Journ. Sci., 3d ser., vol. 35, pp. 490-491.

On nephrite and jadeite. Proc. U. S. Nat. Mus., vol. 11, pp. 115-130. (With F. W. Clarke.)

The Fayette County, Texas, meteorite. Am. Journ. Sci., vol. 36, pp. 113-119, 3 figs. (With J. E. Whitfield.)

On the San Emigdio meteorite. Proc. U. S. Nat. Mus., vol. 11, pp. 161-167, pl. 35.

On a peridotite from Little Deer Isle, in Penobscot Bay, Maine. Proc. U. S. Nat. Mus., vol. 11, pp. 191-195, pl. 34.

On the serpentine of Montville, N. J. Proc. U. S. Nat. Mus., vol. 11, pp. 105-111, pls. 31, 32.
Concerning the Montville serpentine. Science, vol. 11, p. 302.

1889

On the ophiolite of Thurman, Warren County, New York, with remarks on the Eozoon canadense. Am. Journ. Sci., 3d ser., vol. 37, pp. 189-191.
[Preliminary notes on eruptive rocks collected about Fort Ellis and in Gallatin Valley, Montana.] Eighth Rep. U. S. Geol. Surv., J. W. Powell, Director, pp. 147-148.
The collection of building and ornamental stones in the United States National Museum, a handbook and catalogue. Rep. Smithsonian Inst., 1886, pt. 2, pp. 277-648, pls. 1-9.
Among the Pennsylvania slate quarries. Sci. Am. Suppl., vol. 27, no. 681, pp. 10874-10875.

1890

An account of the progress in petrography for the years 1887 and 1888. Rep. Smithsonian Inst., 1888, pt. 1, pp. 327-354.
Notes on the serpentinous rocks of Essex County, N. Y., from aqueduct shaft 26, New York City, and from near Easton, Pennsylvania. Proc. U. S. Nat. Mus., vol 12, pp. 595-600.

1891

Preliminary handbook of the department of geology in the U. S. National Museum. Rep. U. S. Nat. Mus. for 1888-89, Appendix E, pp. 1-50.
Stones for building and decoration. 453 pp. Wiley and Sons, New York. (Second edition, 506 pp., 1897.) (3d edition, 551 pp., 1903.)
A marble quarry. St. Nicholas Magazine, Aug., 2 pp., 2 illustrations.

1892

On some basic eruptive rocks in the vicinity of Lewistown and Auburn, Androscoggin County, Maine. Am. Geol., vol. 10, pp. 49-55.
The wind as a factor in geology. Eng. Mag., vol. 2, pp. 596-597.
Handbook for the department of geology in the U. S. National Museum. Pt. 1, Geognosy.—The materials of the earth's crust. Rep. U. S. Nat. Mus. for 1890, pp. 503-591, pls. 118-129.
Discussion of the strength and weathering qualities of roofing slate. Trans. Am. Soc. Civil Eng., vol. 27, pp. 685-687.
On an azure-blue pyroxenic rock from the Middle Gila, New Mexico. Am. Journ. Sci., 3d ser., vol. 43, pp. 279-280. (With R. L. Packard.)
The building stone industry of the United States. Stone, July, pp. 131-139; Aug., pp. 263-268, 2 pls., 1 fig. in text; Sept., pp. 369-374, 3 pls., 2 figs. in text.
A cheap form of box for microscopic slides. Science, Nov. 25, p. 298.

The marble region of Knoxville, Tennessee. Stone, Nov., pp. 591-599, 1 map and 5 figs. in text.

1893

Notes on the petrography of the Paleozoic section in the vicinity of Three Forks, Montana. Bull. U. S. Geol. Surv., no. 110, pp. 47-54.

The newer eruptive rocks [of Nantasket area]. Boston Soc. Nat. Hist., Occ. Papers, IV, vol. 1, pt. 1, pp. 31-44.

The architect and his materials. The Am. Architect and Building News, Mar. 4, p. 134.

Report upon rocks collected from the Galapagos Islands. Bull. Mus. Comp. Zool., vol. 16, no. 13, pp. 235-237.

1894

[Beaver Creek meteorite]. Am. Journ. Sci., 3d ser., vol. 47, p. 435.

On the formation of stalactites and gypsum incrustations in caves. Proc. U. S. Nat. Mus., vol. 17, pp. 77-81, pls. 2-5.

Geological sketch of Lower California. Bull. Geol. Soc. America, vol. 4. pp. 489-514, pl. 19. (With S. F. Emmons.)

1895

The onyx marbles: Their origin, composition, and uses, both ancient and modern. Rep. U. S. Nat. Mus. for 1893, pp. 539-585, pls. 1-18.

Directions for collecting rocks and for the preparation of thin sections. Bull. U. S. Nat. Mus., no. 39, pt. 1, pp. 1-15, 17 figs.

The formation of sandstone concretions. Proc. U. S. Nat. Mus., vol. 17, pp. 87-88, pl. 6.

Notes on some eruptive rocks from Gallatin, Jefferson and Madison Counties, Montana. Proc. U. S. Nat. Mus., vol. 17, pp. 637-673.

Disintegration of the granitic rocks of the District of Columbia. Bull. Geol. Soc. America, vol. 6, pp. 321-332, pl. 16.

1896

Disintegration and decomposition of diabase at Medford, Massachusetts. Bull. Geol. Soc. America, vol. 7, pp. 349-362, pl. 16.

An occurrence of free gold in granite. Am. Journ. Sci., 4th ser., vol. 1, pp. 309-311.

The principles of rock weathering. Journ. Geol., vol. 4, pp. 704-724, 850-871.

Notes on asbestos and asbestiform minerals. Proc. U. S. Nat. Mus., vol. 18, pp. 281-299.

On the composition and structure of the Hamblen County, Tennessee, meteorite. Am. Journ. Sci., 4th ser., vol. 2, pp. 149-155, figs. 1, 2.

The onyx marbles: Their origin, composition, and uses, both ancient and modern. Stone, vol. 12, pp. 116-121, 228-236, 326-330, 425-429, 559-564; vol. 13, pp. 9-12, 116-120, pls. 5-18.

1897

Notes on the geology and natural history of the peninsula of Lower California. Rep. U. S. Nat. Mus. for 1895, pp. 969-994, pls. 1-10.

A treatise on rocks, rock weathering, and soils. 8 vo. xx and 411 pp., 25 pls., 42 figs. The Macmillan Co., New York.

Weathering of micaceous gneiss in Albemarle County, Virginia. Bull. Geol. Soc. America, vol. 8, pp. 157-168.

1898

A trip across Lower California. The Osprey, vol. 3, pp. 20-25, pls. 3-5.

The physical, chemical, and economic properties of building stones. Maryland Geol. Surv., vol. 2, pp. 47-123.

1899

A discussion on the use of the terms rock weathering, serpentinization, and hydrometamorphism. Geol. Mag., dec. IV, vol. 6, pp. 354-358; Am. Geol., vol. 24, pp. 244-250.

Preliminary note on new meteorites from Allegan, Michigan, and Mart, Texas. Science , new ser., vol. 10, pp. 770-771.

A consideration of some little known American ornamental stones. Stone, vol. 19, pp. 225-230.

1900

Sandstone disintegration through the formation of interstitial gypsum. Science, new ser., vol. 11, p. 850.

Nepheline-melilite basalt from Oahu, Hawaiian Islands. Am. Geol., vol. 25, pp. 312-313.

A new stony meteorite from Allegan, Michigan, and a new iron meteorite from Mart, Texas. Proc. Wash. Acad. Sci., vol. 2, pp. 41-68, 6 pls. (With H. N. Stokes.)

The Marsh collection of vertebrate fossils. Am. Geol., vol. 25, pp. 171-173.

1901

The department of geology in the National Museum. Am. Geol., vol. 28, pp. 107-123, 5 pls.

On a stony meteorite which fell near Felix, Perry County, Alabama, May 15, 1901. Proc. U. S. Nat. Mus., vol. 24, pp. 193-198, 2 pls.

Guide to the study of the collections in the section of applied geology—the non-metallic minerals [U. S. National Museum]. Ann. Rep. U. S. Nat. Mus. for 1899, pp. 156-483, 30 pls., 13 figs.

1902

A newly found meteorite from Admire, Lyon County, Kansas. Proc. U. S. Nat. Mus., vol. 24, pp. 907-913, 7 pls.

What constitutes a clay? Am. Geol., vol. 30, pp. 318-322.

Rutile mining in Virginia. Eng. and Min. Journ., vol. 73, p. 351; Science, new ser., vol. 15, p. 389 (Abstract of paper read before the Geological Society of Washington).

1903

A newly found meteorite from Mount Vernon, Christian County, Kentucky. Am. Geol., vol. 31, pp. 156-158.

John Wesley Powell. Am. Geol., vol. 31, pp. 327-333, 1 pl. (port.).

The quantitative classification of igneous rocks. A review. Am. Geol., vol. 32, pp. 48-54.

On the glacial pothole in the National Museum. Smithsonian Misc. Coll., vol. 45, pp. 100-103, 1 pl.; Sci. Am. Suppl., vol. 58, p. 23844, 1 fig., 1904.

Stones for building and decoration. Third edition. xi and 551 pp., 33 pls., 24 figs. Wiley and Sons, New York.

The diamond mines of South Africa. A review. Am. Geol., vol. 31, pp. 51-53.

1904

The non-metallic minerals, their occurrence and uses. 414 pp., 32 pls., 28 figs. Wiley and Sons, New York.

1905

Catalogue of the type and figured specimens of fossils, minerals, rocks, and ores in the department of geology, United States National Museum. Part 1.—Fossil invertebrates. Bull. U. S. Nat. Mus., no. 53, pt. 1, 704 pp.

On the origin of veins of asbestiform serpentine. Bull. Geol. Soc. America, vol. 16, pp. 131-136, 2 pls., 2 figs.

Gold and its associations. Eng. and Min. Journ., vol. 79, pp. 902-903.

The division of applied geology, United States National Museum. Am. Inst. Min. Eng., Bi-mo. Bull. no. 4, pp. 929-937.

1906

A treatise on rocks, rock weathering and soils. New edition. 400 pp., 31 pls., 42 figs. The Macmillan Company, New York.

A new meteorite from Scott County, Kansas. Science, new ser., vol. 23, pp. 391-392.

The development of the glacial hypothesis in America. Pop. Sci. Monthly, vol. 68, no. 4, pp. 300-322.

On a new stony meteorite from Modoc, Scott County, Kansas. Am. Journ. Sci., 4th ser., vol. 21, pp. 356-360.

Contributions to the history of American geology. Ann. Rep. U. S. Nat. Mus. for 1904, pp. 189-733, 37 pls., 141 figs.

The building and ornamental stones of North Carolina. Bull. North Carolina Geol. Surv., no. 2, pp. 1-283. Collaborator with F. B. Laney and Thomas L. Watson.

University training of engineers in economic geology. Econ. Geol., vol. 1, no. 4, pp. 387-391.

1907

Catalogue of the type and figured specimens of fossils, minerals, rocks, and ores in the department of geology, United States National Museum. Part II.—Fossil vertebrates; fossil plants; minerals, rocks, and ores. Bull. U. S. Nat. Mus., no. 53, pt. 2, 370 pp.

On a newly found meteorite from Selma, Dallas County, Alabama. Proc. U. S. Nat. Mus., vol. 32, pp. 59-61, 2 pls.

Notes on the composition and structure of the Hendersonville, North Carolina, meteorite. With chemical analyses by Wirt Tassin. Proc. U. S. Nat. Mus., vol. 32, pp. 79-82, 2 pls., 1 fig.

On the meteorite from Rich Mountain, Jackson County, North Carolina. Proc. U. S. Nat. Mus., vol. 32, pp. 241-244, 1 pl.

On a peculiar form of metamorphism in siliceous sandstone. Proc. U. S. Nat. Mus., vol. 32, pp. 547-550, 1 pl.

Contributions to the study of the Canyon Diablo meteorites. Smithsonian Misc. Coll., vol. 50 (Quart. Issue, vol. 4, pt. 2), pp. 203-215, pls. 18-21, text figs. 48, 49. (With Wirt Tassin.)

1908

The meteor crater of Canyon Diablo, Arizona; its history, origin, and associated meteoric irons. Smithsonian Misc. Coll., vol. 50 (Quart. Issue, vol. 4, pt. 4), pp. 461-498, 15 pls., 6 figs.

Carl Ludwig Rominger. Smithsonian Misc. Coll., vol. 52 (Quart. Issue, vol. 5, pt. 1), pp. 79-82, 1 fig. (port.)

Edward Travers Cox. Smithsonian Misc. Coll., vol. 52 (Quart. Issue, vol. 5, pt. 1), pp. 83-84, 1 fig. (port.).

1909

A heretofore undescribed stony meteorite from Thomson, McDuffie County, Georgia. Smithsonian Misc. Coll., vol. 52 (Quart. Issue, vol. 5, pt. 4), pp. 473-476, 2 pls.

The composition of stony meteorites compared with that of terrestrial igneous rocks, and considered with reference to their efficacy in world making. Am. Journ. Sci., 4th ser., vol. 27, pp. 469-474.

Coon Butte or Meteor Crater. Abstract. Science, new ser., vol. 29, pp. 239-240.

The Meteor Crater of Arizona. Australasian Assoc. Adv. Sci., Rep. Twelfth meeting, Brisbane, pp. 320-323, 4 figs.

1910

Memoir of W[illiam] S[mith] Yeates. Bull. Geol. Soc. America, vol. 20, pp. 618-619, 1 pl. (port.).
The non-metallic minerals, their occurrence and uses. Second edition, revised. 432 pp., 38 pls., 55 figs. Wiley and Sons, New York.

1911

On the supposed origin of the moldavites and like sporadic glasses from various sources. Proc. U. S. Nat. Mus., vol. 40, pp. 481-486, 2 pls. Abstract. Bull. Geol. Soc. America, vol. 22, no. 4, p. 736.
The fossil forests of Arizona. 23 pp., 7 figs. Washington.

1912

A second meteoric find from Scott County, Kansas. Proc. U. S. Nat. Mus., vol. 42, pp. 295-296, 1 pl.
A recent meteorite fall near Holbrook, Navajo County, Arizona. Smithsonian Misc. Coll., vol. 60, no. 9, 4 pp.
A newly found meteoric iron from Perryville, Perry County, Missouri. Proc. U. S. Nat. Mus., vol. 43, pp. 595-597, 2 pls.

1913

Dana, the geologist. Bull. Geol. Soc. America, vol. 24, no. 1, pp. 64-68.
A newly found meteorite from near Cullison, Pratt County, Kansas. Proc. U. S. Nat. Mus., vol. 44, pp. 325-330, 2 pls.
On the minor constituents of meteorites. Am. Journ. Sci., 4th ser., vol. 35, pp. 509-525.
The "fossil forests" of Arizona. Am. Mus. Journ., vol. 13, no. 7, pp. 311-316, 8 figs.

1915

The Fisher, Polk County, Minnesota, meteorite. Proc. U. S. Nat. Mus., vol. 48, pp. 503-506, 1 pl.
Report on some carbonic acid tests on the weathering of marbles and limestones. Proc. U. S. Nat. Mus., vol. 49, pp. 347-349.
On the monticellite-like mineral in meteorites, and oldhamite as a meteoric constituent. Proc. Nat. Acad. Sci., vol. 1, no. 5, pp. 302-308, 5 figs.
Researches on the chemical and mineralogical composition of meteorites. Proc. Nat. Acad. Sci., vol. 1, no 7, pp. 429-431.
Notes on the composition and structure of the Indarch, Russia, meteoric stone. Proc. U. S. Nat. Mus., vol. 49, pp. 109-112, pl. 37.

1916

Handbook and descriptive catalogue of the meteorite collections in the United States National Museum. Bull. U. S. Nat. Mus., no. 94, 207 pp., 41 pls.

Report on researches on the chemical and mineralogical composition of meteorites, with especial reference to their minor constituents. Mem. Nat. Acad Sci., vol. 14, mem. 1, 29 pp.

Chemical and mineralogical composition of meteorites. (Abstracts with discussion by O. C. Farrington.) Bull. Geol. Soc. America, vol. 27, no. 1, p. 50.

Review of *Meteorites, their structure, composition, and terrestrial relations,* by O. C. Farrington. Science, vol. 44, pp. 314-315.

A recently found iron meteorite from Cookeville, Putnam County, Tennessee. Proc. U. S. Nat. Mus., vol. 51, pp. 325-326, 1 pl.

Notes on the Whitfield County, Georgia, meteoric irons, with new analyses. Proc. U. S. Nat. Mus., vol. 51, pp. 447-449, 1 pl.

A newly found meteoric stone from Lake Okechobee, Florida. Proc. U. S. Nat. Mus., vol. 51, pp. 525-526.

1917

A new find of meteoric stones near Plainview, Hale County, Texas. Proc. U. S. Nat. Mus., vol. 52, pp. 419-422, 2 pls.

On the calcium phosphate in meteoric stones. Am. Journ. Sci., 4th ser., vol. 43, pp. 322-324, 1 fig.

1918

A second meteorite find in Florida [Eustis, Lake Co.]. Am. Journ. Sci., 4th ser., vol. 45, pp. 64-65.

A peculiar fibrous form of opal. Am. Mineralogist, vol. 3, no. 2, pp. 11-12.

Further notes on the Plainview, Texas, meteorite. Proc. U. S. Nat. Mus., vol. 54, pp. 503-505, 2 pls.

On the Fayette County, Texas, meteorite finds of 1878 and 1900, and the probability of their representing two distinct falls. Proc. U. S. Nat. Mus., vol. 54, pp. 557-561, 2 pls., 2 figs.

Tests for fluorine and tin in meteorites with notes on maskelynite and the effect of dry heat on meteoric stones. Proc. Nat. Acad. Sci., vol. 4, no. 6, pp. 176-180, 1 pl.

Lazulite in an unusual form. Am. Mineralogist, vol. 3, no. 11, p. 192.

1919

The composition and structure of meteorites compared with that of terrestrial rocks. Ann. Rep. Smithsonian Inst. for 1917, pp. 175-188, 9 pls., 4 figs.

The percentage number of meteorite falls and finds considered with reference to their varying basicity. Proc. Nat. Acad. Sci., vol. 5, no. 2, pp. 37-39.

A heretofore undescribed meteoric stone from Kansas City, Missouri. Proc. U. S. Nat. Mus., vol. 55, pp. 95-96, 2 pls.

Second report on researches on the chemical and mineralogical composition of meteorites. Mem. Nat. Acad. Sci., vol. 14, mem. 4, 15 pp., 5 pls., 4 figs.
The Cumberland Falls meteorite. Science, new ser., vol. 50, p. 90.

1920

Contributions to a history of American state geological and natural history surveys. Bull. U. S. Nat. Mus., no. 109, 549 pp., 37 pls. (portraits).
The Cumberland Falls, Whitley County, Kentucky, meteorite. Proc. U. S. Nat. Mus., vol. 57, pp. 97-105, 5 pls., 1 fig.
Notes on the meteorite of Estherville, Iowa, with special reference to its included "peckhamite" and probable metamorphic nature. Proc. U. S. Nat. Mus., vol. 58, pp. 363-370, 3 pls.
On chondrules and chrondritic structure in meteorites. Proc. Nat. Acad. Sci., vol. 6, no. 8, pp. 449-472, 1 pl., 17 figs.
Obituary, Joseph Paxson Iddings. Am. Journ. Sci., 4th ser., vol. 50, p. 316.
A retrospective view of the origin of Meteor Crater, Arizona. Pub. Astr. Soc. Pacific, no. 189, pp. 1-6, pl. 7, text fig. 1.

1921

On the mineral composition and structure of the Troup meteorite. Proc. U. S. Nat. Mus., vol. 59, pp. 477-478, pl. 102.
On metamorphism in meteorites. Bull. Geol. Soc. America, vol. 32, pp. 395-416, pls. 2-6.

1922

On meteoric irons from Alpine, Brewster County, Texas, and Signal Mountain, Lower California, and a pallasite from Cold Bay, Alaska. Proc. U. S. Nat. Mus., vol. 61, art. 4, pp. 1-4, pls. 1, 2.
Meteoric iron from Odessa, Ector County, Texas. Am. Journ. Sci., vol. 3, pp. 335-337, 1 fig.
Handbook and descriptive catalogue of the collection of gems and precious stones in the United States National Museum. Bull. U. S. Nat. Mus., no. 118, pp. 1-225, pls. 1-14, text figs. 1-26. (Assisted by Margaret W. Moodey and Edgar T. Wherry.)
A meteoric iron from Owens Valley, California. Mem. Nat. Acad. Sci., vol. 19, mem. 4, pp. 1-7, pls. 1, 2.
Observations of falling meteorites. Science, n. s., vol. 55, pp. 675, 676.

1923

On a recently found meteoric iron from Glasgow, Barren County, Kentucky. Am. Journ. Sci., vol. 5, pp. 63, 64.
A newly found iron meteorite from Somerset County, Pennsylvania. Am. Journ. Sci., vol. 5, pp. 175, 176.

A meteoric metabolite from Dungannon, Virginia. Proc. U. S. Nat. Mus., vol. 62, art. 18, pp. 1, 2, pls. 1, 2.

The department of geology of the United States National Museum. Rep. Smithsonian Inst. for 1921, pp. 261-302, pls. 1-20. Also issued separately and sold under the title *Illustrated handbook, the department of geology of the United States National Museum.*

The New Baltimore, Somerset County, Pennsylvania, meteoric iron. Supplemental note. Am. Journ. Sci., vol. 6, pp. 262-264.

Report on cooperative educational and research work carried on by the Smithsonian Institution and its branches. Smithsonian Misc. Coll., vol. 76, no. 4, 30 pp.

Recently found meteoric irons from Mesa Verde Park, Colorado, and Savannah, Tennessee. Proc. U. S. Nat. Mus., vol. 63, art. 18, pp. 1-4.

1924

The first one hundred years of American geology. Pp. i-xxi, 1-773, 36 pls., 130 figs. in text. Yale University Press.

On a stony meteorite from Anthony, Harper County, Kansas, and a recently found meteoric iron from Mejillones, Chile. Proc. Nat. Acad. Sci,. vol. 10, no. 7, pp. 306-312, pls. 1-3.

On a meteoric iron from Four Corners, San Juan County, New Mexico. Proc. Nat. Acad. Sci., vol. 10, no. 7, pp. 312-318, pls. 1-3.

Quartz in meteorites. Amer. Mineralogist, vol. 9, pp. 112, 113, fig. 1.

1925

A new meteoric stone from Baldwyn, Mississippi. Proc. U. S. Nat. Mus., vol. 67, art. 6, pp. 1, 2, pl. 1.

Notes on the meteoric stone of Colby, Wisconsin. Proc. U. S. Nat. Mus., vol. 67, art. 2, pp. 1-3, pl. 1.

Radio talks on science. Meteors. Sci. Monthly, vol. 21, pp. 456-461.

Supplemental notes. In E. O. Hovey, A new meteoric stone from Johnstown, Weld County, Colorado. Amer. Mus. Novitates, no. 203, pp. 7-13, figs. 5, 6.

1926

The present condition of knowledge on the composition of meteorites. Proc. Amer. Philos. Soc., vol. 65, no. 2, pp. 119-130.

1927

A stony meteorite from Forksville, Mecklenberg County, Virginia. Proc. U. S. Nat. Mus., vol. 70, art. 21, pp. 1-4, pls. 1-3.

A recently found iron meteorite from Oakley, Idaho. Proc. U. S. Nat. Mus., vol. 71, art. 21, pp. 1-3, pls. 1, 2.

Heretofore undescribed meteoric irons from [1] Bolivia, South America, [2] western Arkansas, and [3] Seneca Township, Michigan. Proc. U. S. Nat. Mus., vol. 72, art. 4, pp. 1-4, pls. 1, 2.

Two noted mineral collections. Sci. Monthly, Oct., pp. 314-320, figs. 1-7.

On newly discovered meteoric irons from the Wallapai (Hualapai) Indian Reservation, Arizona. Proc. U. S. Nat. Mus., vol. 72, art. 22, pp. 1-4, pls. 1-3.

Biographical Memoir George Ferdinand Becker, 1847-1919. Nat. Acad. Sci., vol. 21, 2d memoir, pp. 1-19, portrait.

Visits to the serpentine district of southern England and the gem cutting town of Oberstein, Germany. Smithsonian Misc. Coll., vol. 78, no. 7, pp. 21-23, figs. 27-34.

1928

Concerning the origin of metal in meteorites. Proc. U. S. Nat. Mus., vol. 73, art. 21, pp. 1-7, pls. 1-3.

1929

A newly found meteoric stone reported by W. B. Lang from Peck's Spring, Midland County, Texas. Proc. U. S. Nat. Mus., vol. 75, art. 16, pp. 1, 2, pl. 1.

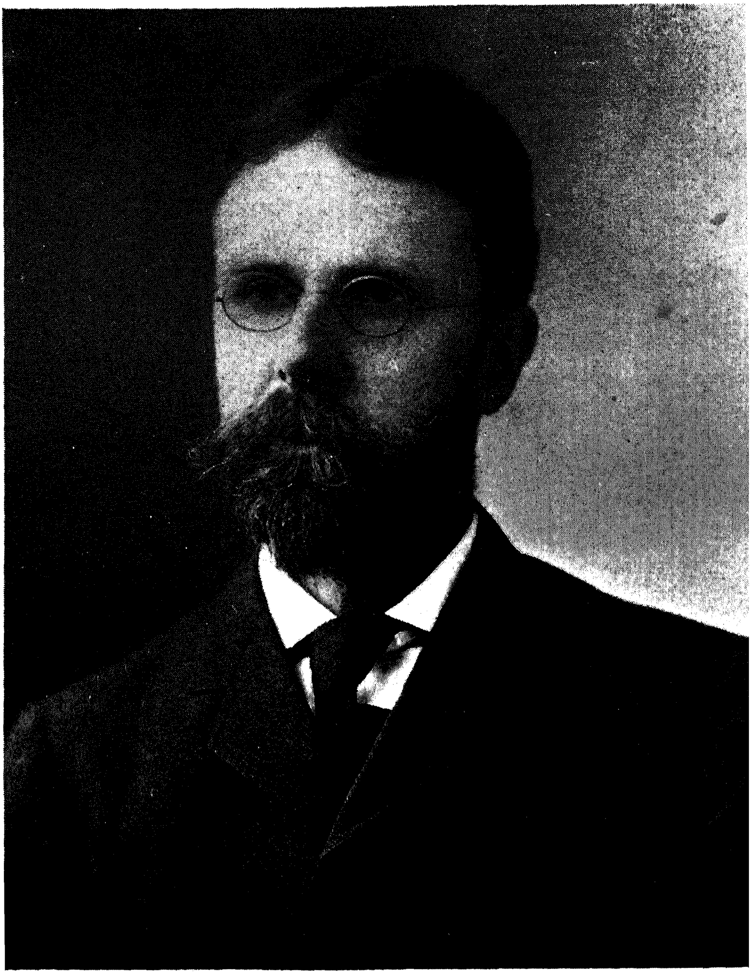
The story of meteorites. Minerals from earth and sky. Smithsonian Scientific Series, vol. 3, pt. 1, pp. 1-163, frontispiece, pls. 1-42, figs. 1-7.

A visit to the mineral producing regions of New England. Expl. and Field-work of the Smithsonian Inst., pp. 5, 6, fig. 3.

1930

Composition and structure of meteorites. Bull. 149, U. S. Nat. Mus., pp. i-vi, 1-62, frontispiece, pls. 1-32.

In addition to the titles given above, Doctor Merrill was a contributor to the Standard Dictionary; Johnson's Universal Cyclopedia; Sturgis's Dictionary of Architecture; Nelson's Encyclopedia; Bailey's Cyclopedia of American Agriculture; and Dictionary of American Biography.



Roland Thaxter.

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVII—THIRD MEMOIR

BIOGRAPHICAL MEMOIR

OF

ROLAND THAXTER

1858–1932

BY

G. P. CLINTON

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1935

ROLAND THAXTER

1858-1932

BY G. P. CLINTON

So far as the writer has been informed there have been written only four biographies, more or less extended, of Professor Roland Thaxter since his death at Cambridge, Massachusetts, on April 22nd, 1932. Two of these appeared in the official publications of Harvard University. One of them, published in the Harvard University Gazette of January 7, 1933, is a minute on his life and services placed upon the records of the Faculty of Arts and Sciences and was written by his fellow botanists at Harvard—Professors Fernald, Robinson and Weston. The second, signed by "H.W.H.", was printed in the Seventh Report of Secretary, Harvard Class of 1882, of which Thaxter was a member. The remaining two articles are by Professor W. H. Weston, Jr., who was Dr. Thaxter's successor at Cambridge. These last two are more extended and are illustrated by three pictures,—two taken by Weston at the time of Thaxter's 70th birthday at Kittery Point, mentioned here later, and the third, taken about the same time, in his laboratory at Cambridge. As all of these show Thaxter as an older man, we use a photograph showing him in his prime taken over thirty years ago. From the preceding sources and our acquaintance with Professor Thaxter and his writings, we present the facts given here.

To write intelligently about a person, one should know something about his ancestry, training, ambitions and the work he accomplished. We believe that from all of these sources Roland Thaxter received or made the elements that contributed to his success as a famous botanist and a successful man. To start with he came from a New England ancestry that was much ahead of that of the average individual. His father, Levi Thaxter, was a Harvard graduate, a lawyer and a student of the poet Browning whose works he brought to favorable attention of the American public. Furthermore, Roland Thaxter's

grandfather and great grandfather, on the paternal side, were educated men as indicated by their graduation from Harvard. His mother, Celia (Laighton) Thaxter, was prominent in the literary world as shown by her books—"Among the Isles of Shoals," "Poems," "An Island Garden," illustrated by Childe Hassam, and "Letters of Celia Thaxter," edited by two of her many friends. We understood that his uncle, Oscar Laighton, also wrote concerning "Ninety Years on the Isles of Shoals" since his father and Thaxter's grandfather had been a lighthouse keeper at White Island, and Oscar Laighton had spent many years there and at Appledore, another of the islands.

It was in sight of these islands that Roland Thaxter made his summer home at Kittery Point, Maine. From his mother he evidently inherited his artistic tendencies and from his father his regard for scientific accuracy and from both his interest in nature. From his mother he also received his love for the sea. This was very deep seated as indicated in her writings, especially her first poem called "Landlocked." In a department store at Boston over thirty years ago, the writer purchased a print of White Island Light with Celia Thaxter's picture in one corner and the last verse of her poem which reads:

"O Earth! thy summer song of joy may soar
Ringing to heaven in triumph. I but crave
The sad caressing murmur of the wave
That breaks in tender music on the shore."

This very sentiment reflects the nature of her son, a quiet, imaginative man who loved the sea and life not for their boisterous moments but for the quiet, more useful periods, yet who, with his mother, knew the hardships of both life and sea.

So when Roland Thaxter, third son and youngest child of Levi and Celia Thaxter, was born at Newtonville, Mass., on the 28th of August in 1858 he inherited the mental traits to give him a good start on his way to fame if he chose to make the necessary sacrifices. That he was anxious thus to succeed is shown by his work at the old Alden school at West Newton, the Boston Latin school, and a private school at Cambridge, as well as at Harvard University. From the latter he graduated with the class of 1882 with an A.B. degree, having *Magna Cum Laude*

honors. The year after graduation was said to have proved somewhat unprofitable to him because of illness. In the fall of 1883 he entered the Harvard Medical School, where he spent part of two years studying medicine.

Before completing his medical course he received a Harris Fellowship in the Harvard Graduate School and so from 1886 to 1888 he was Professor Farlow's assistant in Cryptogamic Botany as well as working on the thesis for his doctor's degree. Previously he had published several small papers (listed here, 1-10) relating to insects. His first important paper (11) was that describing the species of Gymnosporangium and connecting them with their Roestelia stages, published in 1887. This investigation no doubt was inspired by the previous work of Farlow. Thaxter's doctor's thesis (12), published in 1888, was along a line he was most interested in and was entitled "The Entomophthoreae of the United States." Both of these papers showed that here was a young man who was on his way to make a name for himself. The latter paper also revealed that he was a botanist with unusual artistic merit as indicated by the fine, accurate drawings shown in the eight large plates that accompanied the monograph.

In 1887 Dr. Thaxter was married to Mabel Gray Freeman, and in the early summer of 1888 he came to New Haven, having been appointed botanist of the Connecticut Agricultural Experiment Station. Concerning Thaxter's appointment to the Station, "H.W.H." writes about the recommendation and acceptance as follows: " 'He is a competent botanist but he is given to imagination'—'That is just the sort of man we want,' said Professor Johnson, then head of the Station."

During the comparatively short time Thaxter was at the Station he accomplished much pioneer but valuable work. While this Station was the first one to be established in the United States, its work at the beginning was chiefly along chemical lines and the botanical department was not started until after the Hatch Act was passed for all of the State Stations. So Thaxter was not the first Station botanist in this country but rather was Arthur, then of the Geneva Station in New York, the second Station to be established. While at New Haven,

ably will always remain so, for though he was largely a pioneer in this group his work is not that of a pioneer. Whether the many genera and the hundreds of species he described will remain intact we do not know but, since men seem always to tear down whatever precedes them on this earth, no doubt there will be changes. However, it will take self confident and, we hope, brilliant men as well, to further investigate this group.

It was Thaxter's ability as an artist that also gave him prestige as a botanist not only with the Laboulbeniales but with his studies of other fungi which he usually illustrated with accurate and detailed pen-and-ink drawings. No doubt he was anxious to rival the Tulasne brothers for their work on "Selecta Fungorum Carpologia," though he did not have the experience of C. Tulasne in making his drawings directly on the copper engraving plates.

It was in the Proceedings and Memoirs of the American Academy of Arts and Sciences that Thaxter published most of the descriptions and drawings of the Laboulbeniales. In the Proceedings he published his first article (20) in 1890 and the last one (78) in 1920, twenty-one papers in all, and these were chiefly descriptions of new species and their relationships. In the Memoirs he dealt with Monographs (41, 58, 86, 87, 90) of the group in five large volumes, beginning with No. I issued in 1896 and ending with No. V in 1931 shortly before his death. While he did not finish his task as completely as he wished, still he was fortunate to go as far as he did with his poor health and failing eyesight. He also published in the Proceedings a few papers on other fungi, etc. The most important of these were his first paper (11) on fungi, dealing with the relationships of Gymnosporangium and Roesteliae published in 1887 and one of his last papers, entitled "A Revision of the Endogoneae," published thirty-five years later (82). The Academy, as well as Thaxter, should have credit for the generous reproductions of the excellent drawings made in the Memoirs. They represent many hundreds of species made in a total of 166 plates issued, number V of the series alone having 60 plates with over a thousand drawings.

On the whole Thaxter was an extensive traveler to various

parts of the new world as well as in Europe. Everywhere he went he was looking for something new to collect in his line whether it was fungi on living plants and animals, in the streams, woods and fields, or fungi on insects in the various museums he visited. We have mentioned Kittery Point as a collecting place and also New Haven, where, besides the economical fungi, he collected others of less importance. One of these was a new species of smut, *Urocystis hypoxyis* (31) found in West Rock Park near Judges Cave on Star grass and which has rarely been found since. One of his earlier health and collecting trips was made in 1888 in the mountains of Tennessee and North Carolina to which he returned again in 1896. A result of these two trips was the finding of an unusual fungus that he later described as new under the name *Wynnea americana* (56). Even before these trips Weston records botanical and entomological trips that Thaxter made in Newfoundland in 1885 and to the White Mountains in 1886. During the winter of 1890-1891 he went to Jamaica where he secured numerous coprophilus fungi, two genera of which were of special interest and described as new in one of his articles (53). In his sabbatical year of 1897-1898, he collected in Florida and then went to Europe to study and collect Laboulbeniales in the museums of Paris, London and Oxford. He returned again to Europe in 1900 for similar work. He also made one or two other trips to Europe. His sabbatical year of 1912-1913 was partly spent collecting in the British West Indies.

It was around Cambridge, however, that he collected most frequently not only for himself but for his classes. Here he could find species of Gymnosporangia, fresh water inhabiting fungi (36, 37, 39, 40) as well as marine algae. The writer went with him on one of these collecting trips and had a hard time trying to keep up with the strides of his long legs. Through Thaxter's knowledge of this region and encouraged by his directions, we succeeded in finding new and interesting fungi as no doubt did others of his students.

It was during his sabbatical vacation in 1905-1906 to South America that Thaxter had his most extended and possibly his most interesting trip. He went as far south as the Straits of

Magellen in the winter of 1906. A short account (59) of this is given in his "Notes on Chilean Fungi" published in the Botanical Gazeztte in December, 1910. An account of the trip was also made the subject of his talk to the Botanical Society of America, of which he was President in 1909. He took this office only on condition that he should make no set after-dinner Presidential address. Apparently much of the material he collected on this trip has not yet been worked up for publication.

Because of poor health Thaxter did not attend scientific meetings as frequently as did most other botanists. This was especially true in his later years when apparently he was pressed for time to accomplish the work he had laid out for himself. In 1896 he became associate editor of the Botanical Gazette and for eight years he continued in that capacity. Here he published most of his early and later articles that dealt with fungi outside of the Laboulbeniales. Perhaps the most important of his articles published in the Botanical Gazette was one dealing with a new order of Myxobacteriaceae (29) which appeared in January, 1893, and which was followed by two shorter articles on the same subject (43, 55). His last contribution to this publication was his biography of Professor Farlow whom he held in highest esteem. In 1907 he succeeded Farlow as the American editor of the Annals of Botany which position he held until his death. While he aided his students and his American colleagues in publishing articles in this British magazine, he never used it for his own publications.

It was not until 1901 that Thaxter was elected to a full Professorship at Harvard though we have understood that he received the salary sometime before, since Farlow had turned over most of the teaching to him. This was during the two years the writer was in attendance in his laboratory. Up to this time no one had received a doctor's degree under him so there was an impression among the advanced students that he was too critical in granting such degrees and the term "Thaxterized" was used to indicate this severity. However, this was really an indication that Thaxter was careful to whom he granted such honors. Furthermore, Thaxter was just as critical of the work of contemporaneous botanists if he did not

believe that their publications indicated real merit. This criticism was not loudly spoken and was rarely made for general publication.

For a man of a retiring nature Thaxter received as many honors as usually come to famous botanists. There were named in his honor a genus (Thaxteria) and more than six species of fungi as well as two species of lichens. He was President of the New England Botanical Club, the Society of Plant Morphology and Physiology, the American Mycological Society, as well as of the American Botanical Society. He held membership in other American societies, such as the Natural History Society and the American Association for the Advancement of Science and was especially honored by election to the American Academy of Arts and Sciences, the American Philosophical Society and the National Academy of Sciences. He was also a foreign member of the Russian Mycological Society, Linnean Societies of London and Lyons, Royal Botanical Society of Belgium, Royal Academies of Sweden and Denmark, Botanical Society of Edinburgh, Academy of Science of the Institute of France, British Mycological Society and Deutsche Botanisch Gesellschaft. His greatest honor, apparently, was the conferring on him for his work on the Laboulbeniales of the Prix Desmaziers by the French Academy.

But what can be said of Thaxter as a man other than as a botanist and an artist? We know little of his activities outside of his profession as a teacher and an investigator. He certainly was no society man since he did not have the inclination to spend much of his time in such affairs. He was, moreover, a man who hated to waste any time on trivial or needless matters. Even Farlow, whom he reverenced as shown by writing four biographies of him, seemed frivolous of his time compared with Thaxter. During our graduate-student days Farlow each morning would go through the advanced laboratory into Thaxter's room and after a short period Thaxter would accompany him back to the former's room always in conversation, but it seemed to us that this also was an effort on Thaxter's part to save time. Even when a student went to Thaxter's room for help, the latter usually kept on with his work while listening

to him. He was early to his work and usually late in quitting and in his summer vacation was usually collecting, studying his specimens or making drawings of them. When Blakeslee, Weston and the writer met him at Kittery Point, on the occasion of his 70th birthday, to present the volume of congratulatory letters from his former students and contemporary American and European botanists, we found him busy making the final drawings of the Laboulbeniales in the attic workshop of his summer home. His only complaint then was of his failing eyesight in slowing up this work.

In conclusion we can only add that here was a quiet, dignified man and a real scientist, possibly a visionary one as has been said, but to our mind one with the nature of a poet as expressed by his attractive smile that showed his pleasure rather than through an ordinary laugh. By a real scientist we do not mean the political scientist who agitates for laws concerning his occupation, nor an advertising one who seeks newspaper fame through so-called important discoveries, nor yet a director scientist who builds up some important institution through the generous contributions of outsiders and the work of sub-collaborators. But we do mean a scientist who made his own collections and when necessary the media on which he cultivated them, who studied them microscopically and made detailed drawings of them, and then wrote his papers for publication in current periodicals, all of this with little or no outside help or advice. It is of such a man that we write with admiration as a true, worthwhile scientist.

BIBLIOGRAPHY OF ROLAND THAXTER

1. Hibernation of *Amphipyra pyramidoides*. Psyche 1: 106-107. Oct. 1875, issued Nov. 12-29.
2. *Catocala relicta* at Newtonville, Mass. Psyche 1: 112. Oct. 1875, issued Nov. 12-29. (Merely a brief note.)
3. Notes on Attaci. Psyche 1: 194-195. Sept. 1876, issued Nov. 10.
4. List of Noctuidae taken about Newton, Mass. Psyche 2: 34-39. May-June 1877, issued July 9.
5. Additions to the List of Newton Noctuidae. Psyche 2: 80. Sept.-Oct. 1877, issued March 8, 1878.
6. Notes on some Noctuid Larvae found about Newton, Mass. Psyche 2: 121-123. March-April 1878, issued Sept. 24.

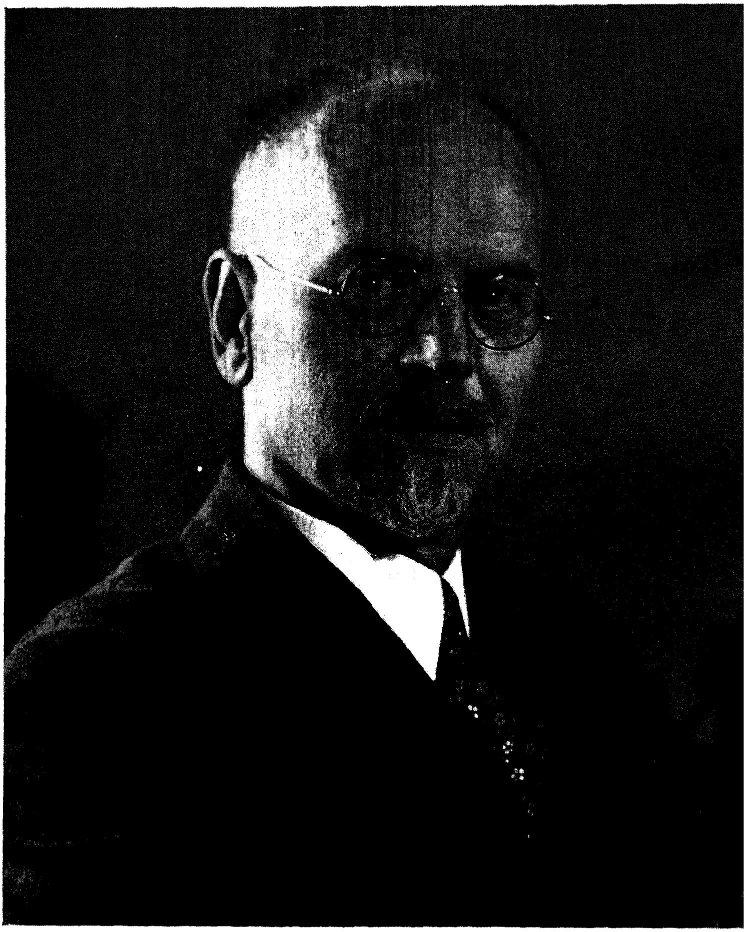
7. Interesting Captures. Psyche **2**: 154. May-Aug. 1878, issued Nov. 8. (Merely a brief note.)
8. Swarming of Archippus. Can. Entom. **12**: 33-39. Feb. 1880.
9. Description of Noctuid Larvae found on Cutt's Island, Maine. Papilio **3**: 10-19. Jan. 1883.
10. Life Histories of Five Species of Scopelosoma. Can. Entom. **16**: 29-34. Feb. 1884.
11. On Certain Cultures of Gymnosporangium, with Notes on their Roesteliae. Proc. Amer. Acad. Arts Sciences **22**: 259-269. 1887. (Separates, Jan. 1887.) Also in Cent. Bactr. Par. **1**: 429-434, 457-460. 1887.
12. The Entomophthoreae of the United States. Mem. Boston Soc. Nat. Hist. **4**: 133-201. *pl.14-21.* April 1888.
13. Injurious Fungi. Rept. Conn. Bd. Agr. **1888**: 42-64. Jan. 1889.
14. Fungous Diseases of Plants. Conn. Agr. Exp. Stat. Bull. 97: 1-2. April 1889.
15. Notes on Cultures of Gymnosporangium made in 1887 and 1888. Bot. Gaz. **14**: 163-172. July 1889.
16. A new American Phytophthora. Bot. Gaz. **14**: 273-274. Nov. 1889.
17. Fungi and Fungicides. Rept. Conn. Bd. Agr. **1889**: 269-280. Jan. 1890.
18. Fungicides. Conn. Agr. Exp. Stat. Bull. 102: 1-7. March 1890.
19. Report of Roland Thaxter, Mycologist: Introductory Note. On Certain Fungus Diseases of the Onion (*Allium Cepa*): The "Smut" on Onions (*Urocystis Cepulae Frost*); The Onion Mildew (*Peronospora Schleideni* Ung.), The Onion Macrosporium (*Macrosporium sarcinula* Berk. variety *parasiticum* Thüm.), The Larger Onion Macrosporium (*Macrosporium Porri* Ell.), The Onion Vermicularia (*Vermicularia circinans* Berk.), Notes on some other Diseases of Onion due to Fungi. Mildew of Lima Beans (*Phytophthora Phaseoli* Thaxter). Miscellaneous Notes. Experiments with Bordeaux Mixture. Notes in Answer to Inquiries concerning Injurious Insects. Conn. Agr. Exp. Stat. Rept. **1889**: 127-180. *pl. 1-3.* 1890.
20. On some North American Species of Laboulbeniaceae. Proc. Amer. Acad. Arts Sciences **25**: 5-14. 1890.
21. The Potato Scab. Conn. Agr. Exp. Stat. Bull. 105: 3-4. Dec. 1890.
22. Supplementary Note on North American Laboulbeniaceae. Proc. Amer. Acad. Arts Sciences **25**: 261-270. 1891.
23. On Certain New or Peculiar North American Hyphomycetes. I. Bot. Gaz. **16**: 14-26. *pl. 3-4.* Jan. 1891. II. *Ibid:* 201-205. *pl. 19-20.* July 1891.
24. Food Plants of some Bombycidae and Noctuidae not included in H. Edward's Catalogues. Can. Entom. **23**: 34-36. Feb. 1891. (Correction, *Ibid.:* 92.)
25. The Connecticut Species of Gymnosporangium (Cedar Apples). Conn. Agr. Exp. Stat. Bull. 107: 1-6. April 15, 1891. (Reprinted in **1891** Report, published in 1892.)

26. Report of the Mycologist: The Potato "Scab." Miscellaneous Notes. Some Results from the Application of Fungicides. Fungicides and their Application. Conn. Agr. Exp. Stat. Rept. **1890**: 80-113. *pl. 1-4.* 1891.
27. Further Results from the Application of Fungicides to Prevent the "Spot" of Quince (*Entomosporium maculatum*). Potato Scab. The Connecticut Species of Gymnosporangium (Cedar Apples). Fungus in Violet Roots. Conn. Agr. Exp. Stat. Rept. **1891**: 150-167. *pl. 1.* 1892.
28. Further Additions of the North American Species of Laboulbeniaceae. Proc. Amer. Acad. Arts Sciences **27**: 29-45. June 1892.
29. On the Myxobacteriaceae, a New Order of Schizomycetes. Bot. Gaz. **17**: 389-406. *pl. 22-25.* Dec. 1892. *Ibid.* **18**: 29-30. Jan. 1893.
30. Notes on *Phallogaster saccatus.* Bot. Gaz. **18**: 117-121. *pl. 9.* April 1893.
31. Fungi described in recent Reports of the Connecticut Experiment Station. Journ. Myc. **7**: 278-280. May 15, 1893.
32. New Species of Laboulbeniaceae from various Localities. Proc. Amer. Acad. Arts Sciences **28**: 156-188. June 1893.
33. New Genera and Species of Laboulbeniaceae, with a Synopsis of the Known Species. Proc. Amer. Acad. Arts Sciences **29**: 92-111. Jan. 1894.
34. Observations on the Genus Naegelia of Reinsch. Bot. Gaz. **19**: 49-55. *pl. 5.* Feb. 1894.
35. Notes on Laboulbeniaceae, with Description of New Species. Proc. Amer. Acad. Arts Sciences **30**: 467-481. Jan. 1895.
36. New or Peculiar Aquatic Fungi. I. Monoblepharis. Bot. Gaz. **20**: 433-440. *pl. 29.* Oct. 1895.
37. New or Peculiar Aquatic Fungi. II. Gonapodya Fischer and Myrioblepharis, *nov. gen.* Bot. Gaz. **20**: 477-485. *pl. 31.* Nov. 1895.
38. New or Peculiar American Zygomycetes. I. Dispira. Bot. Gaz. **20**: 513-518. *pl. 34.* Dec. 1895.
39. New or Peculiar Aquatic Fungi. III. Blastocladia. Bot. Gaz. **21**: 45-52. *pl. 3.* Feb. 1896.
40. New or Peculiar Aquatic Fungi. IV. Rhipidium, Sapromyces and Araiospora, *nov. gen.* Bot. Gaz. **21**: 317-331. *pl. 21-23.* June 1896.
41. Contribution toward a Monograph of the Laboulbeniaceae. Part I. Mem. Amer. Acad. Arts Sciences **12**: 187-429. *pl. 1-26.* Dec. 1896.
42. Review on the "Recherches sur la structure des Mucorinées by Maurice Léger." Bot. Gaz. **23**: 389-390. May 1897.
43. Further Observations on the Myxobacteriaceae. Bot. Gaz. **23**: 395-411. *pl. 30-31.* June 1897.
44. New or Peculiar Zygomycetes. II. Syncephalastrum and Syncephalis. Bot. Gaz. **24**: 1-15. *pl. 1-2.* July 1897.
45. Monographie des Laboulbeniacées. Rev. Myc. **21**: 105-114. *pl. 191-196.* 1889. *Ibid.* **22**: 11-25. *f. 1, pl. 202.* 1900. (This is really a

résumé and extract by R. Ferry and H. Schmidt but credited to Thaxter.)

46. Preliminary Diagnosis of New Species of Laboulbeniaceae. I. Proc. Amer. Acad. Arts Sciences 35: 151-209. Dec. 1899.
47. Preliminary Diagnosis of New Species of Laboulbeniaceae. II. Proc. Amer. Acad. Arts Sciences 35: 407-450. April 1900.
48. Note on the Structure and Reproduction of Compsopogon. Bot. Gaz. 29: 259-267. *pl. 21.* April 1900.
49. Preliminary Diagnosis of New Species of Laboulbeniaceae. III. Proc. Amer. Acad. Arts Sciences 36: 395-414. March 1901.
50. Preliminary Diagnosis of New Species of Laboulbeniaceae. IV. Proc. Amer. Acad. Arts Sciences 37: 19-45. June 1901.
51. Preliminary Diagnosis of New Species of Laboulbeniaceae. V. Proc. Amer. Acad. Arts Sciences 38: 7-57. June 1902.
52. Notes on the Genus Herpomyces. Science II. 17: 463. March 20, 1903.
53. New or Peculiar North American Hyphomycetes. III. Bot. Gaz. 35: 153-159. *pl. 4-5.* March 1903.
54. Mycological Notes, 1-2. 1. A New England Choanephora. 2. Notes on Monoblepharis. Rhodora 5: 97-108. *pl. 46.* April 1903.
55. Notes on the Myxobacteriaceae. Bot. Gaz. 37: 405-416. *pl. 26-27.* June 1904.
56. A New American Species of Wynnea. Bot. Gaz. 39: 241-247. *pl. 4-5.* April 1905.
57. Preliminary Diagnosis of New Species of Laboulbeniaceae. VI. Proc. Amer. Acad. Arts Sciences 41: 301-318. July 1905.
58. Contribution toward a Monograph of the Laboulbeniaceae. Part II. Mem. Amer. Acad. Arts Sciences 13: 217-469. *pl. 28-71.* June 1908.
59. Notes on Chilean Fungi. I. Bot. Gaz. 50: 430-442. *pl. 18-19.* Dec. 1910.
60. New or Critical Laboulbeniales from the Argentine. Proc. Amer. Acad. Arts Sciences 48: 153-223. Sept. 1912.
61. Preliminary Descriptions of New Species of Rickia and Trenomyces. Proc. Amer. Acad. Arts Sciences 48: 363-386. Sept. 1912.
62. Note on the Ascosporic Condition of the Genus Aschersonia Montagne. Bot. Gaz. 57: 308-313. *f. 1-7.* April 1914.
63. Review: "The Fungi which cause Plant Disease. By F. L. Stevens." Rhodora 16: 79-80. April 1914.
64. Laboulbeniales Parasitic on Chrysomelidae. Proc. Amer. Acad. Arts Sciences 50: 15-50. May 1914.
65. On Certain Peculiar Fungus-Parasites of Living Insects. Bot. Gaz. 58: 235-253. *pl. 16-19.* Sept. 1914.
66. New or Peculiar Zygomycetes. III. Blakeslea, Dissophora, and Haplosporangium, *nova genera.* Bot. Gaz. 58: 353-366. *pl. 26-29.* Oct. 1914.
67. New Indo-Malayan Laboulbeniales. Proc. Amer. Acad. Arts Sciences 51: 1-51. Aug. 1915.

68. New or Critical Species of Chitonomyces and Rickia. Proc. Amer. Acad. Arts Sciences **52**: 1-54. June 1916.
69. New Laboulbeniales, chiefly Dipterophilous American Species. Proc. Amer. Acad. Arts Sciences **52**: 647-721. May 1917.
70. Extra-American Dipterophilous Laboulbeniales. Proc. Amer. Acad. Arts Sciences **53**: 695-749. July 1918.
71. New Laboulbeniales from Chile and New Zealand. Proc. Amer. Acad. Arts Sciences **54**: 205-232. Sept. 1918.
72. George Francis Atkinson. Amer. Journ. Bot. **6**: 301-302. July 1919. With portrait. (Joint author with Farlow and Bailey.)
73. William Gilson Farlow. Harvard Grad. Mag. **28**: 269-277. Dec. 1919. With portrait.
74. William Gilson Farlow. Bot. Gaz. **69**: 83-87. Jan. 1920. With portrait.
75. Second Note on Certain Peculiar Fungus-Parasites of Living Insects. Bot. Gaz. **69**: 1-27. *pl. 1-5.* Jan. 1920.
76. William Gilson Farlow. Amer. Journ. Sci. **49**: 87-95. 1920. With portrait.
77. William Gilson Farlow. Amer. Jour. Bot. **7**: 173-181. May 1920. With portrait. (Joint author with Blakeslee and Trelease.)
78. New Dimorphomyceteae. Proc. Amer. Acad. Arts Sciences **55**: 209-282. May 1920.
79. Lincoln Ware Riddle. Science II. **54**: 9. July 1, 1921. (Joint author with Osterhout and Fernald.)
80. Lincoln Ware Riddle. Rhodora **23**: 181-184. Aug. 1921.
81. Reliquiae Farlowianae. Distributed from the Farlow Herbarium of Harvard University. Mycologia **14**: 99-103. May 1922, issued June 6.
82. A Revision of the Endogoneae. Proc. Amer. Acad. Arts Sciences **57**: 289-350. *pl. 1-4.* June 1922.
83. Note on Two Remarkable Ascomycetes. Proc. Amer. Acad. Arts Sciences **57**: 423-436. *pl. 1-2* + *f. 1-2.* Sept. 1922.
84. Introduction to "Lichenes in Insula Trinidad a Professore R. Thaxter Collecti, by Edward A. Vainio." Proc. Amer. Acad. Arts Sciences **58**: 129-147. Jan. 1923.
85. Edited, with notes and two plates, by Thaxter: "The Genera Midotis, Ionomidotis and Cordierites, by Elias J. Durand." Proc. Amer. Acad. Arts Sciences **59**: 1-18. *pl. 1-2.* Sept. 1923.
86. Contribution toward a Monograph of the Laboulbeniaceae. III. Mem. Amer. Acad. Arts Sciences **14**: 309-426. *pl. 1-12.* Nov. 10, 1924.
87. Contribution toward a Monograph of the Laboulbeniaceae. IV. Mem. Amer. Acad. Arts Sciences **15**: 427-580. *pl. 1-24.* Sept. 13, 1926.
88. The Farlow Library and Herbarium of Cryptogamic Botany. Harvard Alumni Bull. **29**: 679-686. March 17, 1927.
89. Note on *Myxotheca hypocreoides* and its Synonymy. Mycologia **19**: 160-164. *f. 1-2.* July-Aug. 1927.
90. Contribution toward a Monograph of the Laboulbeniaceae. V. Mem. Amer. Acad. Arts Sciences **16**: 1-435. *pl. 1-60.* June 27, 1931.



E. W. Washburn

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVII—FOURTH MEMOIR

BIOGRAPHICAL MEMOIR

OF

EDWARD WIGHT WASHBURN

1881–1934

BY

WILLIAM ALBERT NOYES

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1935

EDWARD WIGHT WASHBURN

1881–1934

BY WILLIAM ALBERT NOYES

Edward Wight Washburn was born at Beatrice, Nebraska, on May 10, 1881. He died, suddenly, of heart failure February 6, 1934. In spite of his all too short life, he has left a record of varied and valuable work which has given him a place of high rank among the chemists of his time.

His son, William de Veer Washburn, has furnished the following account of his ancestry, early life and education on the basis of family records.

I. ANCESTRY

Washburn's. Washburn's ancestry can be traced back through twenty generations of Norman English stock to Sir Roger de Wasserbourn, a Norman knight, with family seats in Great Washburne and Little Washburne in England, and following in an unbroken line, predominantly English, down to Edward Wight Washburn.

In 1626, the ancestor, John Washburn, sailed from Leyden, Holland, to rejoin his wife and children, who had sailed on an earlier voyage to Plymouth, Massachusetts Bay Colony. Edward Wight Washburn was also a descendant of Mary Chilton and John Winslow, who came to America in the Mayflower in 1620. Their daughter, Susanna Winslow, married Robert Latham and their daughter, Hannah Latham, married Joseph Washburn, ancestor of Edward Wight Washburn, about 1700. The subject of this sketch was of the eighth generation of the Washburns in America.

The generation to which John Washburn belonged saw the family moving from Massachusetts Bay to unsettled Central Maine, on China Lake, between the present cities of Augusta and Bangor. With the opening of Northern Maine by the new railroads, the family again moved to that section.

His father, William Gilmor Washburn, went in the 1870's to

the comparatively new town of Beatrice, Nebraska, there to set up a flourishing lumber and brick yard.

He was married in Beatrice in 1880 to Flora Ella Wight, a childhood sweetheart who had travelled west for the wedding. The first of their five children was born on May 10, 1881, in Beatrice and was christened Edward Wight Washburn.

The Washburns of England had been "respectable" middle class gentry, which class has been the backbone of England and of New England. In this country they had been, as a rule, of the pioneer merchant class, with the sons leaving the fathers' employ to set up their own business in neighboring towns or in new territories just opening for settlement.

Wife's ancestry. His wife's ancestry was Dutch, entirely. Her father, Caspar Louis de Veer, was the original buyer of caracas chocolate for the Walter Baker Chocolate firm in Boston, and head buyer for that firm. Her name was indicative of the stock from which she sprang. Her father and mother were both from Surinam (or Dutch Guiana), a Dutch colony over which for three preceding generations "de Veers" had been Governor-Generals. Prior to that "de Veers" had been Dutch soldiering and sailoring knights.

II. CHILDHOOD AND EARLY EDUCATION

Rather a precocious child of the school marvel type, Edward was graduated from Beatrice grammar and high schools with the highest marks attained in those schools up to that time. He read indiscriminately everything available till about the second of his three years in high school (having completed the four year course in three at that school). He studied assiduously, apparently from curiosity and from a love of study.

He had very little aptitude for sports, although he showed a genuine liking for them. He cared little for business or mechanics.

Early in his teens he acquired a special interest in the physical sciences, although the small town corn-belt high school of the 90's was most inadequately equipped to teach these subjects. He exhausted the possibilities of scientific studies in the town high school all too soon. Not dismayed, he spent his savings

and chore-money for texts and for materials imported from Chicago and the east. In his own makeshift laboratory, a "den" assigned to him by his admiring father, he set himself as teacher and student body in scientific subjects. He assigned himself sections of text and laboratory experiments from his manuals and at the end of his three years in high school he had completed the equivalent of a first year college course in physics and chemistry. He acquired a fair knowledge of scientific German from his own efforts.

He had decided to become a research chemist, since that comparatively new field seemed to offer more opportunity, for experiment. Very little encouragement was received from the family in this direction as they were becoming alarmed at the not infrequent explosions and odors emanating from his mysterious "lab," the one room in the house from which they were absolutely debarred.

III. UNIVERSITY

The budding scientist had shown some of his laboratory notes to his high school principal and that gentleman prevailed upon Edward's father to send the young man to college. However, in the eyes of most Nebraskans at that time the State University was good enough and only "snobs" went east to college.

Edward had his heart set on a B.S. from the Massachusetts Institute of Technology and a Ph.D. from Leipzig, but it seemed out of the question. One year exhausted the curriculum in chemistry offered at that time at the University of Nebraska. At the end of that year Edward left school until he could put by enough money to see him through one year at the Institute of Technology.

By teaching science, mathematics, history, English and German, acting as assistant principal, and coaching football and debating at McCook (Nebraska) High School for two years and by saving his money enough was put by for his first year at the Institute. After one year an unexpected income from tutoring carried him through to his B.S. in 1905.

At the Institute of Technology he plunged without hesitation into chemistry as a major subject, with emphasis on research. His contact with Arthur A. Noyes, Professor of

Theoretical Chemistry, persuaded him that further study under such inspiration was at least the equivalent of a Ph.D. abroad. Therefore, when Professor Noyes took over the position of Director of the research laboratory in physical chemistry in 1903, Washburn was one of his earliest research students. He obtained a position as research associate under Dr. Noyes in 1906 and studied there until he received his Ph.D. in 1908.

While at the Institute of Technology he had made the acquaintance of, and spent his spare time in courting, a young lady, Sophie de Veer, who shared many of his tastes and was a close friend of his sisters. The young woman lived next door to the house which the Washburn family had taken when his father and his father's brother returned east to open a lumber yard in Boston in 1902.

Miss de Veer finished a normal school course at the same time that Washburn received his Ph.D. Dr. Washburn went to Urbana, Ill., immediately after graduation to take a position as Associate in Chemistry in the University of Illinois, but on his visits at home came in frequent contact with Miss de Veer, who was teaching kindergarten. In 1910 they were married at the bride's home in Roslindale, Mass.

In 1908, when I wished to secure a man who could develop the division of physical chemistry at the University of Illinois in the direction of modern research as well as teach the subject for both undergraduate and graduate students, I asked my friend, Arthur A. Noyes, to recommend someone whom he considered of unusual promise. He named Dr. Washburn and his judgment was abundantly justified in Washburn's subsequent career. As his thesis for his doctorate he used the optical rotation of raffinose as a marker, by means of which he demonstrated, for the first time, that at least some of the ions in a solution of an electrolyte are hydrated, i.e., that they are combined with water in such a manner that water is carried with the ion as it travels through the solution under the influence of a gradient in the electric potential.

At the University of Illinois Dr. Washburn gathered about him an enthusiastic group of young men who carried on re-

search work under his direction while working for the doctorate. As often happens, the topics studied were more or less connected with his work at the Institute of Technology. A very careful study, both theoretical and practical, was made of the best forms of apparatus for the accurate determination of electrical conductance. The work included a study of both moderately concentrated and of very dilute solutions. Finally methods were developed for the calculation of conductance at infinite dilution.

Since conductance depends partly on the viscosity of the solution, a new and very accurate viscosimeter was developed and used. With this the viscosity of water at different temperatures was determined and also the viscosity of solutions of raffinose, the sugar used in determining the hydration of ions.

A very careful theoretical and experimental study of the iodimetric determination of arsenious acid laid a foundation for the development of the iodine coulometer. Heretofore, the only chemical method considered sufficiently accurate for the quantitative measure of electrical currents was the silver coulometer. Washburn and Bates developed the iodine coulometer to a comparable degree of accuracy, and Bates completed the study, by a careful comparison of the silver and iodine coulometers at the National Bureau of Standards in Washington.

His textbook of Physical Chemistry was published in 1915 and an important table showing the hydrogen ion at the point of apparent neutrality for the indicators in common use was prepared. The use of indicators in practical water analysis was discussed.

Professor Washburn directed the work of the division of physical chemistry at the University of Illinois for eight years, 1908-16. An examination of the list of papers published during this period and during the years immediately following, while work already begun was being completed, reveals the fundamental and important character of the researches which he initiated.

Several of the men who studied with Washburn at this time now hold responsible positions widely scattered over our country.

It is unfortunate that in 1916 the exigencies of the University and the financial needs of his family induced Washburn to leave

the division of physical chemistry and accept a position as head of the department of ceramic engineering. On the other hand, the authorities of the University showed their wisdom in selecting for this position a man thoroughly trained in physical chemistry rather than one trained chiefly in the technique of ceramics. It had been found extremely difficult to secure a man fully competent in the two fields.

Dr. Washburn was head of the department of ceramics for six years. The publications of this period show how conscientiously and intensely he devoted himself to a study of the new field, in which he was working. His most important contributions were on the drying of ceramic ware, on porosity, the relation between the crystalline forms of silica, the viscosity of molten glass and on optical glass.

It was at this time that the Army and Navy were in desperate need of a new supply of optical glass, because the supply from European sources was cut off. Dr. Washburn made some valuable contributions to the study of the problem of manufacturing such glasses.

At the organization meeting of the International Union of Pure and Applied Chemistry, held in London in 1919, the Union approved as one of its projects the compilation of International Critical Tables of Numerical Data of Physics, Chemistry and Technology, and assigned to the United States of America the financial and editorial responsibility for the undertaking. The project was later given the patronage of the International Research Council at its Brussels meeting in 1922.

Dr. Washburn was at the meeting in London and, later, he was asked to undertake the task of preparing the Critical Tables as Editor-in-Chief. In order to do this he resigned his position at the University of Illinois and moved to Washington. There for four years, 1922-26, he worked on the gigantic enterprise of collecting and evaluating all the numerical data of physics, chemistry and technology. With the aid of a competent Board of Editors and a very large band of experts in the various fields, approximately 1000 in all, the work was carried through to completion, and the Critical Tables will long remain as a monument to his ability and steady, self-sacrificing devotion to the execution of an extremely difficult task.

In 1926 he was selected by a group of eminent chemists and physicists as their first choice for appointment as the Chief Chemist of the National Bureau of Standards. Here he had the opportunity to direct the work of the chemists of the Bureau in many different and varied lines and also could undertake, with the aid of able assistants, work of importance in which he had a more personal interest.

His son writes:

"In his eyes, one of his greatest ambitions was reached when he found himself in his own laboratory, with good assistants, freedom from the pressure of students and with cooperation from the Director at the Bureau of Standards. It was at that time that he felt he was finally started in the career for which he had spent almost a lifetime in preparation."

The three most important achievements of this period were:

1. The fractionation and isolation of the constituents of petroleum far more accurately and completely than this had ever been done. Primarily a physical chemist, he showed in this work a mastery of the technical methods of organic chemistry worthy of high praise.

2. Of the crystallization of rubber, in which he had the assistance of five other chemists, his son says:

"What he felt to be the hardest research project he had done was the photographing of crystalline rubber at the Bureau of Standards."

3. After the discovery of the isotope of hydrogen now called deuterium, an achievement for which Harold C. Urey received the Nobel Prize, Dr. Washburn suggested that "heavy water" might be concentrated by electrolysis and undertook experiments to carry out the suggestion. His experiments were successful and provided the first method used in preparing deuterium oxide in quantity. A very large new field of chemistry has been opened up by this method. For a bibliography of deuterium, see Bibliography of Deuterium by Ann R. Young, issued by Pennsylvania State College, Pennsylvania, Aug. 1934.

Dr. Washburn's son, William de Veer Washburn, has furnished me with the following statement of some of his father's characteristics:

"Hobbies. Assiduous study throughout his life of the history

of every civilized country—contract bridge—genealogy of Washburns. He had a strong liking for his briar pipe, cross-word puzzles, detective stories, family circle, dancing (after his wife had taught him to dance), card games of his own invention, long walks.

"He liked to write one-act plays for amateur theatricals.

"He was very reticent except in the family circle or when with intimate friends and did not make close friends easily.

"He was an inveterate punster.

"He was typically absent minded except when at his desk or in the laboratory.

"He read omnivorously—at least one book each night before retiring.

"His only attachments were—his laboratory, his wife, his family.

"In keeping with his usual shyness in public he was a little afraid of formal recognition of his achievements and discouraged very strongly any attempts by his associates to secure publicity for him or his work."

This sketch would not be complete without some further reference to Mrs. Sophie de Veer Washburn, the wife to whom he was so devoted and who meant so much in his life.

She was always deeply devoted to him and to his work. She read the proofs of his publications and in many ways helped to make possible that intense concentration which was such an important factor in his success.

She had, also, a very pronounced individuality of her own. She was devoted to her children, but with the sort of devotion which recognizes the right of a child to develop initiative and personal characteristics of his own. The manner in which the family is carrying on as a unit now that both father and mother are gone, demonstrates that this attitude of the parents has been especially useful in their case.

Mrs. Washburn died in 1932, two years before her husband. There are four children, William de Veer, Janet, Roger D., and Barbara.

Dr. Washburn was chairman of the International Committee on Physico-Chemical Standards, Member of the International Research Council in Brussels in 1919 and 1922, Fellow of the

Royal Society of Arts, Honorary Member and Life Member of the American Ceramic Society (Editor of the Journal 1920-22), Member of the National Academy of Sciences.

BIBLIOGRAPHY OF

EDWARD WIGHT WASHBURN

The theory and practice of the iodimetric determination of arsenious acid. J. Am. Chem. Soc., 30, 31-46 (1908).

Improved apparatus for the measurement of the transference numbers in solutions of halogen acids and their salts. Tech. Quart., 21, 164-77 (1908).

Hydrates in solution. Tech. Quart., 21, 360-449 (1908); Jahrb. Radioakt. Elektronik, 5, 493-552; 6, 69-125.

Determination of hydration of ions by transference experiments in the presence of a non-electrolyte. Tech. Quart., 21, 288-320; J. Am. Chem. Soc., 31, 322-55 (1909).

The influence of salts on the specific rotation of sucrose and raffinose. Z. Ver. Zuckerind., 60, 381-5 (1910).

A simple system of thermodynamic chemistry based on a modification of the method of Carnot. J. Am. Chem. Soc., 32, 467-502 (1910).

The fundamental law for a general theory of solutions. J. Am. Chem. Soc., 32, 653-70 (1910).

The significance of the term alkalinity in water analysis and the determination of alkalinity by means of indicators. Proc. Ill. Water Supply Assoc., 93-101 (1910).

Laws of "concentrated" solutions. II. The estimation of the degree of ionization of electrolytes in moderately concentrated solutions. J. Am. Chem. Soc., 33, 1461-78 (1911).

Cesium nitrate and the mass action law. With D. A. MacInnes. Z. Elektrochem., 17, 503-9; Z. physik. Chem., 40, 218 (1911).

Laws of "concentrated" solutions. III. Ionization and hydration relations of electrolytes in aqueous solutions at 0°. A. $CsNO_3$, KCl, LiCl. With D. A. MacInnes. J. Am. Chem. Soc., 33, 1686-1713 (1911).

The iodine coulometer and the value of the Faraday. With S. J. Bates. J. Am. Chem. Soc., 34, 134-68 (1912).

Laws of "concentrated" solutions. IV. Electrical conductance of concentrated aqueous solutions of electrolytes. Trans. Amer. Electrochem. Soc., 21, 125-41 (1913).

Improved apparatus for measuring the conductivity of electrolytes. With J. E. Bell. J. Am. Chem. Soc., 35, 177-84 (1913).

Laws of "concentrated" solutions V. 1. The equilibrium between arsenious acid and iodine in aqueous solution. 2. A general law for chemical equilibrium in solutions containing ions. 3. The energetics of the reaction between arsenious acid and iodine. With E. K. Strachan. J. Am. Chem. Soc., 35, 681-714 (1913).

Precision viscosimeter for measurement of relative viscosity and the relative viscosities of water at 0°, 18°, 20°, and 50°. With G. Y. Williams. J. Am. Chem. Soc., 35, 750-4 (1913).
The viscosities and conductivities of aqueous solutions of raffinose. With G. Y. Williams. J. Am. Chem. Soc., 35, 309-21 (1913).
The hydration of the ions of cesium chloride derived from transference experiments in the presence of raffinose. With Earl B. Millard. Proc. Natl. Acad. Sci., I, 142-146 (1915).
The measurement of vapor pressure lowering by the air saturation method. With E. O. Heuse. J. Am. Chem. Soc., 37, 309-21 (1915).
The ionic hydration and transference numbers of caesium chloride. With E. B. Millard. J. Am. Chem. Soc., 37, 694-9 (1915).
The freezing-point solubility law for ideal solutions. With J. W. Read. Proc. Natl. Acad. Sci., 1, 191-5 (1915).
Measurement of electrical conductivity. I. Theory of the design of conductivity cells. J. Am. Chem. Soc., 38, 2431-60 (1916).
Two laws governing the ionization of strong electrolytes in dilute solutions and a new rule for determining equivalent conductance at infinite dilution derived from conductivity measurements with extremely diluted solutions of potassium chloride. Proc. Natl. Acad. Sci.,3, 569-77 (1917).
Measurement of electrolytic conductivity. II. Telephone receiver as an indicating instrument for use with the alternating current bridge. With K. Parker. J. Am. Chem. Soc., 39, 235-45 (1917).
The latent heats of fusion of calcium oxide and magnesium oxide. Trans. Am. Ceramic Soc., 19, 195-200 (1917).
The equivalent conductances of electrolytes in dilute aqueous solution. J. Am. Chem. Soc., 40, 106-22 (1918).
Ceramics and the war. Met. Chem. Eng., 18, 253-5 (1918).
The effect of gravitation on the drying of ceramic ware. J. Am. Ceramic Soc., 1, 25-34, (1918).
The place of the university in chemical war work. J. Ind. Eng. Chem., 10, 786-8 (1918).
The presence of iron in the furnace atmosphere as a source of color in the manufacture of optical glass. J. Am. Ceramic Soc., 1, 786-8 (1918).
Refractory materials as a field of research. J. Am. Ceramic Soc., 2, 3-31 (1919).
The new International Union of Pure and Applied Chemistry. Science, 5, 319-23 (1919).
Laws of "concentrated" solutions. VI. 1. The general boiling-point law. With J. W. Read. J. Am. Chem. Soc., 41, 729-41 (1919).
Some aspects of scientific research in relation to the glass industry. J. Am. Ceramic Soc., 2, 855-64 (1919).
Note on the latent heat of fusion of cristobalite. J. Am. Ceramic Soc., 2, 1007-8 (1919).
The extrapolation of conductivity data to zero concentration. II. J. Am. Chem. Soc., 42, 1077 (1920).
Physical chemistry and technology. Chem. Met. Eng., 23, 435-7 (1920).

Factory methods for measuring the viscosity of pot-made glass during manufacture—value of viscosity data to the manufacturer. J. Am. Ceramic Soc., 3, 735-49 (1920).
The Ceramic Industries. Tech. Eng. News, 1, No. 8 (1920).
Approximate determination of the melting-point diagram of the system ZrO_2-SiO_2. With E. E. Libman. J. Am. Ceramic Soc., 3, 634-40 (1920).
The viscosity temperature curves of six varieties of optical glass. With G. R. Shelton. Phys. Rev., 15, 149-50 (1920).
Dissolved gases in glass. With F. P. Footit and E. N. Bunting. Univ. Ill. Eng. Exp. Sta. Bull., 118, (1921).
Porosity. [Partly with F. P. Footit and E. K. Bunting.] I. Purpose of the investigation. II. Porosity and the mechanism of absorption. III. Water as an absorption liquid. IV. Petroleum products as absorption liquids. V. Procedures for determining porosity by methods of absorption. VI. Determination of absorption by the method of gas expansion. VII. Determination of the porosity of highly vitrified bodies. J. Am. Ceramic Soc., 4, 916-22; 961-89 (1921); 5, 48-56; 112-29; 527-37 (1922).
Dynamics of capillary flow. Phys. Rev. 17, 374-5 (1921).
Physical chemistry and ceramics. J. Franklin Inst., 193, 749-73 (1922).
Note on a method of determining the distribution of pore sizes in a porous material. Proc. Natl. Acad. Sci. 7, 115-116 (1921).
The relation of chalcedony to other forms of silica. With L. Navias. Proc. Natl. Acad. Sci., 8, 1-5 (1922).
The products of the calcination of flint and chalcedony. With L. Navias. J. Amer. Ceramic Soc., 5, 565-85 (1922).
Measurement of viscosity and surface tension of viscous liquids at high temperatures. Rec. trav. chim., 42, 686-96 (1923).
Simple and accurate method for determining surface tension and density of molten glass. Proc. Am. Phys. Soc., (1922); Phys. Rev. 20, 94-5 (1922).
The viscosities and surface tension of the soda-lime-silica glasses. With G. R. Shelton and E. E. Libman. Univ. Ill. Exp. Sta. Bull. No. 140, 71 pp. (1924).
Apparatus for determining the melting and freezing points of pure substances and of eutectic mixtures. Ind. Eng. Chem., 16, 275 (1924).
Vapor pressure of ice and water below the freezing point. Monthly Weather Review, 52, 488-90 (1924).
Estimating atomic weights with the aid of the Periodic law. J. Am. Chem. Soc., 48, 2351-2 (1926).
Constancy of pressure during isothermal condensation or vaporization as a criterion for purity. Z. physik. Chem., 130, 592-600 (1927).
Apparatus and method for the separation, identification and determination of the chemical constituents of petroleum. With J. H. Bruun and Mildred M. Hicks. Bureau of Standards J. Research, 2, 467-88 (1929).
Determination of molecular weights in the vapor state from vapor pressure and evaporation data. Bureau of Standards J. Research, 2, 703-13 (1929).

Electric conductance method for determining liquefaction temperature of solids. With E. R. Smith. Bureau of Standards J. Research, **2**, 787-91 (1929).

The principles of measurement and of calculation in their application to the determination of diophantine quantities. Bureau of Standards J. Research, **4**, 221-46 (1930).

The problem of establishing the identity and purity of 6 hydrocarbons obtained from petroleum. Ind. Eng. Chem., **22**, 985-8 (1930).

The determination of the empirical formula of a hydrocarbon. Bureau of Standards J. Research, **5**, 867-90 (1930).

Crystalline rubber hydrocarbon. With C. E. Waters, W. H. Smith, H. J. Wing, F. W. Ashton and C. P. Saylor. Phys. Rev., **38**, 1790-1 (1931).

A twin bomb method for the accurate determination of the pressure-volume-temperature data and a simple method for the measurement of high pressures. Bureau of Standards J. Research, **9**, 271-8 (1932).

Concentration of the H^2 isotope of hydrogen by the fractional electrolysis of water. With H. C. Urey. Proc. Natl. Acad. Sci., **18**, 496-8 (1932).

Calorimetric method for determining the intrinsic energy of a gas as a function of the pressure. Bureau of Standards J. Research, **9**, 521-8 (1932).

Standard states for bomb calorimetry. Bureau of Standards J. Research, **10**, 525-38 (1933).

The work of the National Bureau of Standards in chemistry and metallurgy. Sci. Monthly, 29-30 (1933).

Fractionation of petroleum into its constituent hydrocarbons. Ind. Eng. Chem., **25**, 891-4 (1933).

The isotopic fractionation of water by distillation and adsorption. With E. R. Smith. J. Chem. Physics, **1**, 426 (1933).

Chemical constituents of petroleum, A. P. I. Research project No. 6. Am. Petroleum Inst. Proc., 14th Ann. Meeting, Sect. III, 111-23 (1933).

The isotopic fractionation of water. With E. R. Smith and M. Frandsen. Bureau of Standards J. Research, **11**, 453-62 (1933); J. Chem. Physics, **1**, 288 (1933).

Fractionation of the isotopes of hydrogen and of oxygen in a commercial electrolyzer. With E. R. Smith and F. A. Smith. Bureau of Standards J. Research, **13**, 599-608 (1934).

Note on the phase equilibria in the system Na_2O-TiO_2. With E. M. Bunting. Bureau of Standards J. Research, **12**, 239 (1934).

The isotopic fractionation of water by physiological processes. With E. R. Smith. Science, **79**, 188-9 (1934).

An examination of water from various natural sources for variations in isotopic composition. With E. R. Smith. Bureau of Standards J. Research, **12**, 305-11 (1934).

Methods of inducing crystallization. J. Am. Ceramic Soc., **14**, 138-141 (1935).

BOOKS BY E. W. WASHBURN

An introduction to the principles of physical chemistry from the standpoint of modern atomistics and thermodynamics. Pp. xxv + 445. McGraw-Hill Book Co., New York, 1915. Revised edition, Pp. xxvii + 516. 1921.

Principes de chimie physique du point de vue de l'atomistique et de la thermodynamique modernes. (Translated by H. Weiss and W. Albert Noyes, Jr.) Pp. xvi + 574, Payot, Paris.

International Tables of numerical data, physics, chemistry and technology. Edward Wight Washburn, Editor-in-Chief. Vols. I to VII. McGraw-Hill Book Co., New York. 1926-30.

E H Moore

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVII—FIFTH MEMOIR

BIOGRAPHICAL MEMOIR

OF

ELIAKIM HASTINGS MOORE

1862–1932

BY

G. A. BLISS and L. E. DICKSON

PRESENTED TO THE ACADEMY AT THE AUTUMN MEETING, 1935

ELIAKIM HASTINGS MOORE*

1862–1932

BY G. A. BLISS AND L. E. DICKSON

The great development which has taken place in our American mathematical school during and since the last decade of the last century has been in large part due to the activities of a relatively small group of men whose names and devoted interest are well known to all of us. In our memories and our histories their achievements will be indelibly recorded with grateful appreciation and esteem. One of the leaders among these men, in enthusiasm and scholarship and clearness of vision for the future, was Eliakim Hastings Moore.

He was born in Marietta, Ohio, on January 26, 1862, and died on December 30, 1932, in Chicago, where he was professor and head of the department of mathematics at the University of Chicago. It is interesting to note that the environment in which Moore grew to manhood was a most suitable nursery for the distinction which he afterward attained in so great a measure. His grandfather was an earlier Eliakim Hastings Moore, a banker and treasurer of Ohio University at Athens, Ohio, a county officer and collector of internal revenue, and a Congressman. Eliakim Hastings the younger served as messenger in Congress during one summer vacation while his grandfather was there. His father was a Methodist minister, David Hastings Moore, and his mother was Julia Carpenter Moore of Athens. The family moved from place to place while E. H. Moore was young, as necessitated by the profession of his father, but a considerable part of his childhood was spent in Athens, where one

* The material in this biography is taken from two papers by G. A. Bliss entitled "Eliakim Hastings Moore" and "The Scientific Work of Eliakim Hastings Moore," Bulletin of the American Mathematical Society, vol. 39 (1933), pp. 831-838, and vol. 40 (1934), pp. 501-514. See also the biographical notes by L. E. Dickson, Science, vol. 77 (1933), pp. 79-80; H. E. Slaught, The American Mathematical Monthly, vol. 40 (1933), pp. 191-195; and G. A. Bliss, The University Record of the Unisity of Chicago, vol. 19 (1933), pp. 130-134.

of his playmates was Martha Morris Young, who was afterward to become his wife. His father, D. H. Moore, besides being a preacher, was successively a captain, major, and lieutenant colonel in the Civil War; president of Cincinnati Wesleyan College; an organizer and first chancellor of the University of Denver; editor of the *Western Christian Advocate;* and Bishop of the Methodist Episcopal Church in Shanghai with jurisdiction in China, Japan, and Korea. His was the distinguished career of a man much beloved. Our E. H. Moore, the son of D. H. Moore, was married in Columbus, Ohio, on June 21, 1892, to Martha Morris Young, who survives him. She is a sister of John Wesley Young, late professor of mathematics at Dartmouth College, the memories of whose friendship and achievements are cherished possessions of mathematicians in this country. Her father, William Henry Young of Athens, was a professor at Ohio University, a colonel in the Civil War, and the son of a Congressman. Mrs. Moore herself was before her marriage an instructor of Romance languages at the University of Ohio, and also at the University of Denver during the chancellorship of D. H. Moore. Shortly after their marriage the young couple went to live in Chicago where Mr. Moore had just been appointed professor and acting head of the department of mathematics in the new University of Chicago which opened its doors in the autumn of 1892. Professor and Mrs. Moore have one son, also named Eliakim Hastings Moore, who was graduated from the University of Chicago and who now lives in Texas.

While E. H. Moore was still in high school, Ormond Stone, director of the Cincinnati Observatory, secured him one summer in an emergency as an assistant. Professor Stone was afterward director of the Leander McCormick Observatory of the University of Virginia, and a founder of the Annals of Mathematics which began its career at Virginia, later moved to Harvard, and finally to Princeton. Though primarily an astronomer, Professor Stone had a high appreciation for mathematics, and he inspired his young assistant with a first interest in that science. This interest was later confirmed at Yale University which the student, Moore, had been persuaded to enter by two of his friends, Horace Taft and Sherman Thatcher. The former is

the brother of the late President William Howard Taft, and the latter is a son of a professor at Yale. These two men were Moore's best friends in college, and life long friends thereafter. Curiously enough both of them founded famous schools for boys, one in Watertown, Connecticut, and the other in California. But the man at Yale who had the most profound influence upon E. H. Moore, and who first inspired in him the spirit of research, was Herbert Anson Newton, professor of mathematics and a scientist of distinction. That Moore responded ably to the personal encouragement of Newton, as well as that of Stone, is indicated by his career as an undergraduate. During his college course he took three prizes in mathematics and one each in Latin, English, and astronomy. In his junior year he won the "philosophical oration appointment" and second prize at "junior exhibition," and in his senior year he held the Foote Scholarship and was valedictorian of his class. His nickname was "Plus" Moore. He took his A.B. at Yale in 1883 and his Ph.D. in 1885. Professor Newton, deeply impressed with the ability of the young mathematician, financed for him a year of study at Göttingen and Berlin in return for a promise to pay at some future time.

We have been able to find only meager information concerning the year which Professor Moore spent in Germany. He went first to Göttingen, in the summer of 1885, where he studied the German language and prepared himself for the winter of 1885-6 in Berlin. The professors of mathematics most prominent in Göttingen at that time were Weber, Schwarz, and Klein. At Berlin, Weierstrass and Kronecker were lecturing. We know that Moore was received in friendly fashion and greatly influenced by these distinguished men. It seems that the work of Kronecker made the most lasting impression upon him, but in his habits of mathematical thought and in his later work there are many indications of influences which might be traced to Weierstrass and Klein. There is no doubt that the year abroad affected greatly Professor Moore's career as a scholar. It established his confidence in his ability to take an honorable place in the international as well as our national circle of mathematicians, acquainted him at first hand with the activities of European scien-

tists, and established in him a respect and friendly interest for German scholarship which lasted throughout his life.

When Moore returned to the United States from his sojourn in Europe he entered at once upon his career as teacher, scholar, and independent investigator. His first position was an instructorship in the Academy at Northwestern University in 1886-7. For the next two years he was a tutor at Yale University. In 1889 he returned to Northwestern as assistant professor, and in 1891 he was advanced to an associate professorship. Meanwhile he had published four papers in the field of geometry, and one concerning elliptic functions, and his aggressive genius as a rising young scholar was recognized by President William R. Harper of the newly founded University of Chicago. When the University first opened in the autumn of 1892 Moore was appointed professor and acting head of the department of mathematics. In 1896, after four years of unusual success in organizing the new department, he was made its permanent head, and he held this position until his partial retirement from active service in 1931.

As a leader in his department, Professor Moore was devotedly unsparing of his own energies and remarkably successful. He persuaded President Harper to associate with him two unusually fine scholars, Oskar Bolza and Heinrich Maschke, both former students at Berlin and Ph.D.'s of the University of Göttingen. The three of them supplemented each other perfectly. Moore was brilliant and aggressive in his scholarship, Bolza rapid and thorough, and Maschke more deliberate but sagacious and one of the most delightful lecturers on geometry of all time. They early organized the Mathematical Club of the University of Chicago whose meetings are devoted to research papers, and which continues to meet bi-weekly to the present day. Those of us who were students in those early years remember well the tensely alert interest of these three men in the papers which they themselves and others read before the Club. They were enthusiasts devoted to the study of mathematics, and aggressively acquainted with the activities of mathematicians in a wide variety of domains. The speaker before the Club knew well that the excellencies of his paper would be fully appreciated, but also that its weaknesses would be

discovered and thoroughly discussed. Mathematics, as accurate as our powers of logic permit us to make it, came first in the minds of these leaders in the youthful department at Chicago, but it was accompanied by a friendship for others having serious mathematical interests which many who experienced their encouragement will never forget. With no local precedent or history of any sort to guide them, Moore and Bolza and Maschke, with Moore as the guiding spirit, created a mathematical department which promptly took its place among the group of active centers from which have flowed the influences creative of our present American mathematical school. Their success is recorded not only in published papers, but also in the activities of their students, who are distributed widely in the colleges and universities of this country.

In the lecture room Professor Moore's methods defied most established rules of pedagogy. Such rules, indeed, meant nothing to him in the conduct of his advanced courses. He was absorbed in the mathematics under discussion to the exclusion of everything else, and neither clock time nor meal time brought the discussion to a close. His discourse ended when some instinct told him that his topic for the day was exhausted. Frequently he came to his class with ideas imperfectly developed, and he and his students studied through successfully or failed together in the study of some question in which he was at the moment interested. He was appreciative of rapid understanding, and sometimes impatient when comprehension came more slowly. No one could have been more surprised than he, or more gentle in his expressions of regret, when someone called to his attention the fact that feelings had been hurt by such impatience. It is easy to understand under these circumstances, however, that poor students often shunned his courses, and that good students whose principal interests were in other fields sometimes could not afford the time to take them. But it was a proud moment when one who was ambitious and interested found himself in the relatively small group of those who could stand the pace. It is no wonder that among the ablest mathematicians of our country at the present time those who drew their chief inspiration from Professor Moore are numerous. He was essentially a teacher of those who teach teachers.

Unless we pause to make a computation we often fail to comprehend the rapidity of spread and the magnitude of the influence of such a man.

There is not space here to trace the achievements of the men who were influenced primarily during their student years by Professor Moore. The list of those whose thesis work for the doctor's degree was done under his supervision is, however, a distinguished one. We give it here in the order in which the degrees were taken: L. E. Dickson, H. E. Slaught, D. N. Lehmer, W. Findlay, O. Veblen, T. E. McKinney, R. L. Moore, G. D. Birkhoff, N. J. Lennes, F. W. Owens, H. F. MacNeish, R. P. Baker, T. H. Hildebrandt, Anna J. Pell (Mrs. A. L. Wheeler), A. D. Pitcher, R. E. Root, E. W. Chittenden, M. G. Gaba, C. R. Dines, Mary E. Wells, A. R. Schweitzer, V. D. Gokhale, E. B. Zeisler, J. P. Ballantine, C. E. Van Horn, R. E. Wilson, M. H. Ingraham, R. W. Barnard, H. L. Smith, F. D. Perez.

Professor Moore's success as an educator was due to his profound interest in mathematics and his faculty for inspiring his colleagues, and especially the strongest graduate students, with some of his own enthusiasm. With students not so far advanced he was less successful. His own comprehension was so rapid, and his concentration on the mathematics at hand was so absorbing to him, that he found it hard to comprehend or await the slower development of understanding in the less experienced. But he appreciated the importance of the problems of elementary instruction and at times participated actively in their solution. Not many people remember that in 1897 he edited an arithmetic for use in elementary schools. In 1903-4 and following years he modified radically the methods of undergraduate instruction in mathematics at the University of Chicago, and he himself gave courses in beginning calculus. With characteristic independence he cast aside the text books and concentrated on fundamentals and their graphical interpretations. The courses were so-called laboratory courses, meeting two hours each day, and requiring no outside work from the students. It might be added parenthetically that, as with many such new plans, the amount of work required of the instructor was exceedingly great. The two hour period was the feature which later caused the abandonment of the plan because

of the very practical difficulty in finding hours on schedules which would not interfere with the offerings of other departments. At the present time we are facing serious criticisms of the teaching of mathematics in colleges and high schools. If we are to find a satisfactory answer we must perhaps consider again the deletion of the irrelevant and concentration on fundamentals. The laboratory method too has distinct advantages. It has appealed to many, and has in one form or another been made a part of numerous new plans for the teaching of mathematics. In these educational experiments which Professor Moore undertook, as at every other stage of his leadership in his department, he had one permanent characteristic. He believed in the exercise of individuality in class room instruction, and he gave his colleagues unlimited freedom in the development of their class room methods. He expected and insisted on success, and he was always sympathetically interested in a new proposal or procedure, but so far as is known to us he never prescribed a textbook.

The foundations of Professor Moore's leadership lay undoubtedly in his scholarship. In this biography no adequate description of his investigations can be given. The reader will find an analysis of his more important research activities in the second of the papers to which reference was made above. In his earlier years he was a prolific writer, and his published papers promptly established him as a mathematician of resourcefulness and power. Two of the characteristic qualities of his research were accuracy and generality. He was a master of mathematical logic, and his originality in making one or more theories appear as special instances of a new and more general one was remarkable. We remember a number of meetings of the Mathematical Club of the University of Chicago at which this interest in generalization was characteristically exhibited. At one of them an economist was struggling with the old problem of the selection of a mean for the proper interpretation of certain statistical data. At the next meeting Professor Moore summarized the postulates implied in the paper of the economist, and exhibited the infinite totality of generalized means which they characterized. At another meeting Professor Bolza described some of the properties of a family of

cycloid arches which are important for the brachistochrone problem of the calculus of variations. At the following meeting Professor Moore showed that the class of families of arches with the same properties is indeed a much more general one, as is now well recognized. His success in these and much more important generalizations, especially in the domain of integral equations, culminated in a theory which he called General Analysis and which became his principal interest. In 1906 when he lectured on this theory at the New Haven Colloquium of the American Mathematical Society, he was ahead of the times. In recent years, however, many mathematicians have continued his ideas or have encountered them in independent approaches from other standpoints. Professor Moore's enthusiasm for mathematical research never waned, but in his later years his interest in formal writing declined. This was due primarily, we think, to two reasons. In 1899 he became one of the chief editors of the *Transactions of the American Mathematical Society* and for eight years thereafter he devoted himself unstintingly to the affairs of the journal and of the Society. The value of this work to our mathematical community, then still in its youthful and formative stage, cannot be overestimated. But for Professor Moore himself it had the effect of decreasing markedly the number of his published papers. Later, after others had assumed the responsibilities which he had so long courageously shouldered, he adopted a logical symbolism, largely of his own creation, for the expression of his mathematical ideas to himself and his students. It was not well understood by mathematicians in general, and not well suited for publication in journals. In those days, when research assistants for mathematicians were almost unknown, the translation of his writings from his convenient symbolisms to conventional mathematical language was far less interesting to him than the continuation of his own investigations. The result has been that he has left in symbolic form a great legacy of unpublished research material concerning General Analysis.

It is too early to attempt a judgment of the significance for mathematicians in general of Professor Moore's notations. He was a specialist in symbolisms, every detail of which meant something to him. In thinking or lecturing about mathematics,

others as well as himself have found his notations not only convenient but also a potent aid in the formulation and testing of sequences of logical steps. They are especially effective in the development of theories involving limiting processes. It is true that the important things in mathematics are ideas rather than the symbols by means of which we represent them, but it is evident also that the structure of our science as we know it today would be impossible without the increasingly convenient notations which mathematicians through the ages have successively developed. That Professor Moore was fully conscious of this, and that he regarded notational problems as among the most important and difficult ones which mathematicians have to face, is clearly indicated by his correspondence with the late Professor Florian Cajori in 1919. It was their exchange of letters at that time which led to the preparation and publication in 1928 and 1929 of Cajori's two volumes on *The History of Mathematical Notations.*

It was to be expected that a man so highly regarded as a scientist should become a leader in his university and in the associations of workers in his field. Professor Moore was one of the youngest, but also one of the most spirited, of the notable group of scholars who in the nineties of the last century first shaped the character of the new University of Chicago and gave it great distinction. From the opening day of the University he devoted himself unselfishly to its interests, and his counsel through the years had great influence. At all times he stood unequivocally for the highest ideals of scholarship. His services to the University were signalized in 1929 by the establishment of the Eliakim Hastings Moore Distinguished Service Professorship, one among the few of these professorships which have been named in honor of members of the faculty of the University. The first and present incumbent is Professor Leonard Eugene Dickson. Professor Moore was a moving spirit in the organization of the scientific congress at the World's Columbian Exposition of 1893, and in the first colloquium of American mathematicians held shortly thereafter in Evanston with Klein as the principal speaker. He was influential in the transformation of the local New York Mathematical Society into the American Mathematical Society in 1894, and

in the foundation of the first so-called section of the Society whose meetings were held in or near Chicago and of which he was the first presiding officer in 1897. The formation of the Chicago Section was an outgrowth of the Evanston colloquium. After that meeting a number of mathematicians from universities in and near Chicago occasionally met informally for the exchange of mathematical ideas. After the organization of the American Mathematical Society they applied for and were granted recognition as a section of the Society. It was the success of this first section which led to the establishment, in various parts of the country, of other similar meeting places which have added greatly to the influence and value of the Society. Professor Moore was vice-president of the Society from 1898 to 1900, and president from 1900 to 1902. In 1921 he was president of the American Association for the Advancement of Science. In 1899 he and other aggressive members induced the Society to found the *Transactions of the American Mathematical Society,* now our leading mathematical journal. The first editors were E. H. Moore, E. W. Brown of Yale, and T. S. Fiske of Columbia. These men set standards of editorial supervision which have endured to this day. Professor Moore retired from his editorship in 1907. From 1908 to 1932 he was a non-resident member of the council of the Circolo Matematico di Palermo and of the editorial board of its *Rendiconti*. From 1914 to 1929 he was the chairman of the editorial board of the University of Chicago Science Series. Nineteen volumes were published in the *Series* during that period, two of them, by H. F. Blichfeldt and L. E. Dickson, in the domain of mathematics. From 1915 to 1920 Professor Moore was a member of the editorial board of the *Proceedings of the National Academy of Sciences*. In 1916, by his advice and encouragement, he gave great assistance to Professor H. E. Slaught, who was a moving spirit in the formation of the Mathematical Association of America. In the decades preceding 1890 research scholars in mathematics in America were few and scattered, with limited opportunities for scientific intercourse. At the present time we have a well-populated and aggressive American mathematical school, with frequent opportunities for meetings, one of the world's great centers

for the encouragement of scientific genius. From the record of Professor Moore's activities described above, it is clear that at every important stage in the development of this school he was one of the progressive and influential leaders.

That the distinction of Professor Moore's services to science and education was recognized in other universities as well as his own is indicated by the honors conferred upon him. He received an honorary Ph.D. from the University of Göttingen in 1899, and an LL.D. from Wisconsin in 1904. Since that time he has been awarded honorary doctorates of science or mathematics by Yale, Clark, Toronto, Kansas, and Northwestern. Besides his memberships in American, English, German, and Italian mathematical societies, he was a member of the American Academy of Arts and Sciences, the American Philosophical Society, and the National Academy of Sciences. Two funds have been established in his honor. The first is held by the American Mathematical Society for the purpose of assisting in the publication of his research and for the establishment of a permanent memorial to him in the activities of the Society. The second has been expended for a portrait of him which hangs in Bernard Albert Eckhart Hall for the mathematical sciences at the University of Chicago. The interest in these funds among the friends and admirers of Professor Moore was a remarkable tribute to him scientifically and personally.

The activities too concisely enumerated in the preceding paragraphs were the external evidences of a remarkable personality, a personality beyond the power of the writers of these pages adequately to describe. Professor Moore believed in mathematics, and his life was an unselfish and vigorous expression of his confidence in the importance of the opportunity of studying and teaching his chosen science, not only for himself but also for others who might have the interest and ability. He was sometimes misunderstood when he was impetuous or impatient, but his impatience was rarely personal. It was due almost always to the fact that someone was not understanding mathematics, and that someone might be either another person or himself. In the latter case he was likely to be for the moment unusually restless and irritable. In all of his

activities he sought unceasingly for the truth, and for the words or symbols which might express truth accurately. He had at times a curious hesitation in his speech, characteristic of him, but unaccountable to those who recognized the unusual agility of his mind but who did not know him well. He would hesitate or stop completely in the midst of a sentence, searching among the wealth of words which presented themselves that particular one which would precisely express his meaning, just as in his mathematics he sought always the precisely suggestive symbol. In times of stress his patience with his colleagues was remarkable, and his friendship for them at all times was immovable. He believed in individuality and encouraged independence in their teaching, and he protected them in their research, often at great cost to himself. Outside, as well as in his own department, his enthusiasm, his scientific integrity, and his deep insight established an influence which will extend wherever mathematics is studied and truth is honored, beyond the confines of his country or his day.

THE SCIENTIFIC WORK OF ELIAKIM HASTINGS MOORE

The preceding pages of this memoir are devoted to a biographical sketch of Eliakim Hastings Moore. No account of his life can approximate completeness, however, without a more detailed description of his scientfic activities than was given there. His enthusiasm for mathematical research was a dominant one, more characteristic of him than any other, in spite of the fact that he had many administrative and editorial responsibilities which often interfered seriously with his scientific work. He had a catholic interest in all domains of mathematics and a breadth of knowledge which was remarkable. There have been few men with so great an appreciation of the mathematical efforts of others, or so well qualified to discuss them in many different fields, qualities which were an important part of his insignia of leadership. If there were two characteristics of his research which could be distinguished above others, one could say that they would be rigor and generality. He strove for precision in thought and language at a time when vagueness and uncertainty were common in mathematical literature, and he profoundly in-

fluenced both students and colleagues in this respect by his teaching and example. He was furthermore among the very first to recognize the possibility and importance of the great generality in analysis which is now sought by many writers.

Moore was a prolific thinker, though not throughout his lifetime a prolific writer. His papers, as given in the bibliography at the end of this article, fall roughly into the groups indicated in the following table which lists the numbers of the items in the bibliography belonging to each field and the dates of the first and last papers in each group:

I. Geometry; 1-4, 28, 41, 43-44, 47, 63; 1885-1913.
II. Groups, numbers, algebra; 6-9, 12, 13, 15-18, 20-27, 29, 32, 33, 42, 46, 48, 53, 60, 68, 69, 71; 1892-1922.
III. Theory of functions; 5, 10, 11, 14, 19, 30, 31, 35-40, 52, 59, 67, 73, 74; 1890-1926.
IV. Integral equations, general analysis; 50, 51, 54, 56, 58, 61, 62, 64-66, 70, 75; 1906-1922.
V. Miscellaneous; 34, 45, 49, 55, 57, 72; 1900-1922.

The table indicates fairly well, we think, the sequence of his major interests, though it does not represent adequately the relative enthusiasms with which he pursued them. The domains suggested in the second and fourth entries were the ones to which he gave most thought. His studies in algebra and the theory of groups fell in the period of his greatest activity as a writer, while integral equations and general analysis were his absorbing interest during the latter part of his life when he published least. For general analysis, in particular, he never lost his enthusiasm. He continued his speculations in that field into the last year of his life, as long as his strength permitted.

The comments on Moore's papers in these pages must necessarily be brief. For a more complete synopsis the reader is referred again to the second of the papers to which reference is made on the first page of this memoir. The papers on geometry fall into two groups, an early one concerned with algebraic geometry, which was Moore's first mathematical interest, and a later series of three papers on postulational foundations. The qualities exhibited by Moore in the earlier of these two groups of papers were in many ways characteristic of his research through-

out his life. The theory of linear systems of plane curves, which he freely used, was at that time a central interest in algebraic geometry, as indicated, for example, in numerous papers which appeared between 1884 and 1887 in the *Palermo Rendiconti*. The skill which he showed in handling such systems, and the elegance of his results, are indicative of unusual power in so young a man, and the problems which he studied were fundamental ones for the algebraic geometry of that period. The papers on postulational foundations were inspired by Hilbert's book on the foundations of geometry of 1899 which attracted the attention of Moore and his students to postulational methods, including earlier work of Pasch and Peano as well as that of Hilbert. Moore analysed skillfully questions which had arisen concerning the independence of Hilbert's axioms, and gave a new formulation of a system of axioms for n-dimensional geometry, using points only as undefined elements instead of the points, lines, and planes of Hilbert in the 3-dimensional case.

Moore early became interested in the theory of abstract groups, one of the fields of research in which he was at various times most deeply engaged. An abstract of his first paper in this field, number (6) in the bibliography below, appeared in 1892, but his first published paper was the paper (8, 16) which he presented at the mathematical congress held at the World's Columbian Exposition in Chicago in 1893. It contained a generalization of the modular group, a statement and proof for the first time of the interesting and important theorem which says that every finite algebraic field is a Galois field, and a characterization of a doubly-infinite system of so-called simple groups, only a few of which had been known before. Although Moore's algebraic interests centered largely in groups and their applications to the theory of equations, he was nevertheless actively interested at times in a variety of other algebraic questions, notably the theory of numbers and modular systems. In each of these domains he made interesting and important contributions.

Moore's early interest in the theory of functions was indicated by the relatively simple papers (5) of 1890 and (11) of 1895. A much more important contribution, showing perhaps for the first time his full power in analysis, was his memoir (19) of 1897 concerning transcendentally transcendental functions. It

is a model of clarity and elegance, and gives evidence of his increasing interest and ingenuity in mathematical generalizations. In 1900 mathematicians in this country were greatly interested in an extension by Goursat of a fundamental theorem in the theory of functions, and in the space-filling curves of Peano and Hilbert. Moore's papers (31) and (30) of that year illuminated these topics with an accuracy and clarity characteristic of him. His papers (35, 36, 37) of 1901 on improper definite integrals may with justice be regarded as the climax of the literature on this subject preceding the development of the later and more effective integration theories of Borel and Lebesgue.

But the domains which captured Moore's interest most effectively were the theories of integral equations and general analysis. In the years following 1900 the fundamental papers of Fredholm and Hilbert on integral equations attracted wide attention. Moore saw that the equations which they studied, as well as corresponding and more elementary ones well known in algebra, must be special instances of a much more general linear equation, and he set about the construction of a general theory which should include them all. His guiding principle, as often stated, was that "the existence of analogies between central features of various theories implies the existence of a general abstract theory which includes the particular theories and unifies them with respect to these central features." This principle was the dominant note of his Colloquium lectures (56) delivered before the American Mathematical Society at Yale University in 1906. The lectures were published in 1910, after the appearance of his related paper (54) presented at the International Congress of Mathematicians in Rome in 1909. In these papers and two later ones (58, 61) Moore gave in essential outline his first theory of general analysis and his generalization of preceding theories of linear equations. His attack was highly postulational, and original especially in the fact that the postulates applied to classes of functions rather than to individual ones. He was able to secure for his general theory most of the results which are of interest in the more special cases, but some of them eluded him. The attempts which he made in order to complete the theory in these respects led to such complexities that he finally turned from his first method to a second more constructive theory

of similar character but with a much simpler basis. The results which he attained have appeared in part in his memoirs. They are now being revised by Professor R. W. Barnard and Dr. Max Coral and are being published by the American Philosophical Society.

The titles of the papers in the group designated as "miscellaneous" in the table are for the most part self-explanatory. Three of these should be mentioned more explicitly, however, Moore's addresses (45, 55, 72) as retiring president of the American Mathematical Society in 1902, at the 20th anniversary of Clark University in 1909, and as retiring president of the American Association for the Advancement of Science in 1922. The first contains in its earlier pages an illuminating description of Moore's conception of the logical structures of pure and applied mathematical sciences, the latter part being devoted to a discussion of the pedagogical methods by means of which one might hope to establish such concepts clearly in the minds of students in our schools, colleges and universities. It was written at a time when Moore himself was greatly interested in a laboratory method of instruction for college students of mathematics, and at the height of the so-called Perry movement in England which aroused great interest and discussion among those responsible for instruction in the mathematical sciences in our own country.

The second paper (55) was apparently unpublished and we have as yet found no manuscript. But there is a somewhat informally written paper with nearly the same title and date in the archives of the Department of Mathematics at the University of Chicago. There seems little doubt that it contains the material of the Clark address. It contains a non-technical description of the work of Pasch, Peano, and Hilbert on foundations of geometry, and of the contributions of Cantor, Russell, and Zermelo to the theory of classes.

His address (72) as retiring president of the American Association was also unpublished, but a typewritten copy is extant. It is a description of the historical development of the number systems of mathematics with the purpose of establishing the interesting thesis that mathematical theories, though well recognized as highly deductive in their ultimately sophisticated forms,

are nevertheless the products of inductive developments similar to those well known in the laboratory sciences.

BIBLIOGRAPHY

The abbreviations used are explained at the end of the bibliography. Items marked with an asterisk are titles of more significant abstracts or unpublished addresses.

1. *Extensions of certain theorems of Clifford and Cayley in the geometry of n dimensions,* Transactions of the Connecticut Academy of Arts and Sciences, vol. 7 (1885), pp. 1-18.
2. *Note on space divisions* (with C. N. Little), Journal, vol. 8 (1886), pp. 127-131.
3. *Algebraic surfaces of which every plane section is unicursal in the light of n-dimensional geometry,* Journal, vol. 10 (1888), pp. 17-28.
4. *A problem suggested in the geometry of nets of curves and applied to the theory of six points having multiply perspective relations,* Journal, vol. 10 (1888), pp. 243-257.
5. *Note concerning a fundamental theorem of elliptic functions, as treated in Halphen's Traité, vol.* 1, *pp.* 39-41, Rendiconti del Circolo Matematico di Palermo, vol. 4 (1890), pp. 186-194.

*6. *Concerning a congruence group of order* 360 *contained in the group of linear fractional substitutions,* Proceedings of the American Association for the Advancement of Science, vol. 41 (1892), p. 62.

7. *Concerning triple systems,* Annalen, vol. 43 (1893), pp. 271-285.

*8. *A doubly-infinite system of simple groups,* Bulletin of the New York Mathematical Society, vol. 3 (1893), pp. 73-78; see also No. 16 below.

9. *The group of holoedric transformations into itself of a given group,* Bulletin, vol. 1 (1894), pp. 61-66.
10. *Concerning the definition by a system of functional properties of the function* $f(z) = (\sin \pi z)/\pi$, Annals, (1), vol. 9 (1894), pp. 43-49.
11. *On a theorem concerning p-rowed characteristics with denominator* 2, Bulletin, vol. 1 (1895), pp. 252-255.
12. *Concerning triple systems,* Rendiconti del Circolo Matematico di Palermo, vol. 9 (1895), p. 86.
13. *Concerning Jordan's linear groups,* Bulletin, vol. 2 (1895), pp. 33-43.
14. *A note on mean values,* American Mathematical Monthly, vol. 2 (1895), p. 303.
15. *On an interesting system of quadratic equations* (with Emma C. Ackermann), American Mathematical Monthly, vol. 3 (1896), p. 38.
16. *A doubly-infinite system of simple groups,* Mathematical Papers Read at the International Mathematical Congress in Chicago 1893, published by MacMillan, 1896, pp. 208-242; see also the abstract, No. 8 above.
17. *A two-fold generalization of Fermat's theorem,* Bulletin, vol. 2 (1896), pp. 189-199.

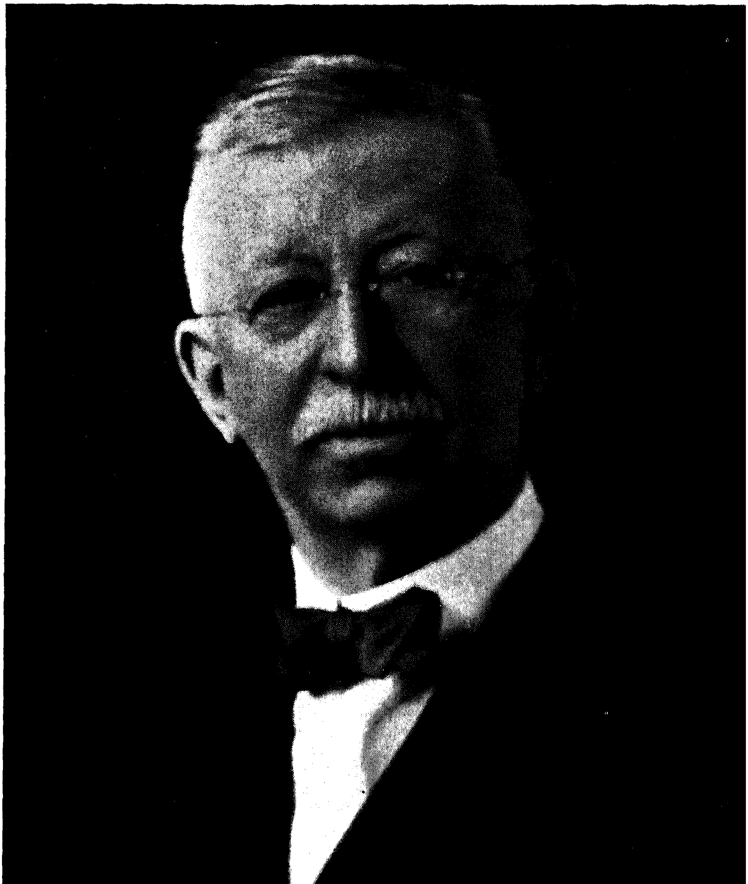
18. *Tactical Memoranda,* I-III, Journal, vol. 18 (1896), pp. 264-303.
19. *Concerning transcendentally transcendental functions,* Annalen, vol. 48 (1897), pp. 49-74.
20. *The decomposition of modular systems of rank n in n variables,* Bulletin, vol. 3 (1897), pp. 372-380.
21. *Concerning the abstract groups of order k! and (k/2)! holoedrically isomorphic with the symmetric and the alternating substitution groups on k letters,* Proceedings of the London Mathematical Society, vol. 28 (1897), pp. 357-366.
22. *Concerning regular triple systems,* Bulletin, vol. 4 (1897), pp. 11-16.
23. *An universal invariant for finite groups of linear substitutions with application in the theory of the canonical form of the linear substitution of finite period,* Annalen, vol. 50 (1898), pp. 213-219.
24. *Concerning abelian-regular transitive triple systems,* Annalen, vol. 50 (1898), pp. 225-240.
*25. *A two-parameter class of solvable quintics, in which the rational relations amongst the roots, by threes, do not contain the parameters,* Bulletin, vol. 4 (1898), p. 364.
26. *Concerning the general equations of the seventh and eighth degrees,* Annalen, vol. 51 (1899), pp. 417-444.
*27. *On the sub-groups of abelian groups,* Bulletin, vol. 5 (1899), pp. 382-383.
28. *The cross ratio group of n! Cremona transformations of order n — 3 in flat space of n — 3 dimensions,* Journal, vol. 22 (1900), pp. 279-291.
29. *A fundamental remark concerning determinantal notation and the evaluation of an important determinant of special form,* Annals, (2), vol. 1 (1900), pp. 177-188.
30. *On certain crinkly curves,* Transactions, vol. 1 (1900), pp. 72-90.
31. *A simple proof of the fundamental Cauchy-Goursat theorem,* Transactions, vol. 1 (1900), pp. 499-506.
32. *Concerning Klein's group of (n + 1)! n-ary collineations,* Journal, vol. 22 (1900), pp. 336-342.
*33. *On the generational determination of abstract groups,* Bulletin, vol. 6 (1900), pp. 379-380.
34. *The undergraduate curriculum* (E. H. Moore et al.), Bulletin, vol. 7 (1900), pp. 14-24.
35. *Concerning Harnack's theory of improper definite integrals,* Transactions, vol. 2 (1901), pp. 296-330.
36. *On the theory of improper definite integrals,* Transactions, vol. 2 (1901), pp. 459-475.
37. *Concerning Du Bois-Reymond's two relative integrability theorems,* Annals, (2), vol. 2 (1901), pp. 153-158.
*38. *On the uniformity of continuity,* Bulletin, vol. 7 (1901), p. 245.
*39. *On double limits,* Bulletin, vol. 7 (1901), p. 257.
*40. *Concerning the second mean-value theorem of the integral calculus,* Bulletin, vol. 8 (1901), pp. 19-20.

41. *On the projective axioms of geometry,* Transactions, vol. 3 (1902), pp. 142-158.
42. *A definition of abstract groups,* Transactions, vol. 3 (1902), pp. 485-492.
43. *The betweenness assumptions,* American Mathematical Monthly, vol. 9 (1902), pp. 152-153.
*44. *On Hilbert's plane arguesian geometry,* Bulletin, vol. 8 (1902), p. 202.
45. *On the foundations of mathematics* (retiring address as president of the American Mathematical Society), Bulletin, vol. 9 (1903), pp. 402-424; also in Science, (2), vol. 17 (1903), pp. 401-416.
46. *The subgroups of the generalized finite modular group,* The Decennial Publications of the University of Chicago (1903), pp. 141-190.
47. *On doubly infinite systems of directly similar convex arches with common base line,* Bulletin, vol. 10 (1904), pp. 337-341.
48. *On a definition of abstract groups,* Transactions, vol. 6 (1905), pp. 179-180.
49. *The cross-section paper as a mathematical instrument,* School Science and Mathematics (1906), pp. 429-450; also in The School Review, vol. 14 (1906), pp. 317-338.
*50. *On the theory of systems of integral equations of the second kind,* Bulletin, vol. 12 (1906), p. 280.
*51. *Homogeneous distributive functional operations of degree n,* Bulletin, vol. 13 (1907), pp. 217-219.
52. *Note on Fourier's constants,* Bulletin, vol. 13 (1907), pp. 232-234.
53. *The decomposition of modular systems connected with the doubly generalized Fermat theorem,* Bulletin, vol. 13 (1907), pp. 280-288.
54. *On a form of general analysis with application to linear differential and integral equations,* Atti del IV Congresso Internazionale dei Matematici (Rome, 6-11 Aprile, 1908), vol. 2 (1909), pp. 98-114.
*55. *The rôle of postulational methods in mathematics* (address at Clark University, 20th anniversary), Bulletin, vol. 16 (1909), p. 41.
56. *Introduction to a form of general analysis,* New Haven Mathematical Colloquium, Yale University Press (1910), pp. 1-150.
57. *A generalization of the game called Nim,* Annals, (2), vol. 11 (1910), pp. 93-94.
58. *On the foundations of the theory of linear integral equations,* Bulletin, vol. 18 (1912), pp. 334-362.
*59. *Multiplicative interrelations of certain classes of sequences of positive terms,* Bulletin, vol. 18 (1912), pp. 444-445.
60. *A mode of composition of positive quadratic forms,* British Association Report, Dundee, vol. 82 (1913), p. 413.
61. *On the fundamental functional operation of a general theory of linear integral equations,* Proceedings of the Fifth International Mathematical Congress (Cambridge, 1912), vol. 1 (1913), pp. 230-255.
*62. *On nowhere negative kernels,* Bulletin, vol. 19 (1913), pp. 287-288.
*63. *On the geometry of linear homogeneous transformations of m variables,* Bulletin, vol. 19 (1913), pp. 457-458.

*64. *On a class of continuous functional operations associated with the class of continuous functions on a finite linear interval,* Bulletin, vol. 20 (1913), pp. 70-71.
65. *Definition of limit in general integral analysis,* Proceedings of the National Academy of Sciences, vol. 1 (1915), pp. 628-632.
*66. *Report on integral equations in general analysis* (address by chairman of Chicago Section), Bulletin, vol. 21 (1915), p. 430.
*67. *On a definition of the concept: limit of a function,* Bulletin, vol. 22 (1916), pp. 439-440.
*68. *On properly positive Hermitian matrices,* Bulletin, vol. 23 (1916), pp. 66-67.
*69. *On the reciprocal of the general algebraic matrix,* Bulletin, vol. 26 (1920), pp. 394-395.
70. *On power series in general analysis,* Annalen, vol. 86 (1922), pp. 30-39.
*71. *On the determinant of a Hermitian matrix of quaternionic elements,* Bulletin, vol. 28 (1922), p. 296.
*72. *What is a number system?,* Bulletin, vol. 29 (1922), p. 91.
73. *A general theory of limits* (with H. L. Smith), Journal, vol. 44 (1922), pp. 102-121.
*74. *Introduction to a theory of generalized Hellinger integrals,* Bulletin, vol. 32 (1926), p. 224.
75. *General analysis,* in press, published by the American Philosophical Society.

List of Abbreviations

Annalen = Mathematische Annalen
Annals = Annals of Mathematics
Bulletin = Bulletin of the American Mathematical Society
Journal = American Journal of Mathematics
Transactions = Transactions of the American Mathematical Society



Edgar F. Smith

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVII—SIXTH MEMOIR

BIOGRAPHICAL MEMOIR

OF

EDGAR FAHS SMITH

1854–1928

BY

GEORGE H. MEEKER

PRESENTED TO THE ACADEMY AT THE AUTUMN MEETING, 1935

EDGAR FAHS SMITH

1854–1928

BY GEORGE H. MEEKER

INTRODUCTORY

The memory of Edgar Fahs Smith shall indefinitely, actively and abundantly remain honored in scientific and academic circles as that of an outstanding American chemist, especially electrochemist; of the inspirational historian of early American chemists and chemistry; of a notable collector of chemical memorabilia; of a distinguished university professor of chemistry; and of an admired and constructive head of the University, and of the Philosophical Society, which the great Benjamin Franklin founded in Philadelphia.

The complete human, civic and scientific record of Dr. Smith goes far beyond these, his memorial landmarks; and possesses that extreme rarity, humanly, of freedom from trace of blemish—of aught to overlook or to condone. As a scientist he ranks with those of high distinction, though not with the few of recognized greatness. As a man his qualities and life works were saintly.

In science, excepting Priestley, he surpassed those early, eminent, American chemists to whose histories he gave such devoted and invaluable service. He thought, labored and produced in the Berzelian motif. As is true of most scientists of note, his discoveries, investigations and inventions possess recognized distinction, but have not epochal quality. He types with the admirably robust and fecund men of science, rather than with the titanic ones. As a man, scientific or otherwise, Edgar F. Smith was unsurpassable. As teacher, academician, administrative head in learned fields, none outranks him.

As a scientist Dr. Smith was essentially a chemist; and as a chemist he consciously, consistently and fruitfully, though not exclusively, labored upon the Berzelian model of precise, extensive, facts and figures, pure and applied, in the inorganic and

mineralogic fields. In a lesser degree, organic and medical chemistry also lured his labors, upon Wöhler and von Liebig models. The modern, physical, mathematical and quasimeta-mathematical chemical domain opened and grew during his maturer life as a chemist. Toward the experimentally factual region of that domain, Dr. Smith had his customary keen interest for all facts of chemistry; toward its flood of speculation he was by his wont, tolerant, though dubious; it did not lure him.

From early youth until his end, Dr. Smith's life flowed undeviatingly, deeply, in serenely simple channels. Quietly, kindly, tolerantly, uprightly, optimistically, busily, he lived; and, as he thus lived, he guided, constructed and so wrought as to leave behind him a truly amazing total of accomplishments for any one man, even for his lifespan of seventy-four years.

ITEMS AND EVENTS

These are to be known through categoried lists which the reader should consult, where hereto later joined, and entitled: "Biographic Sources." In what follows herein, the stated sources have freely been utilized.

THE CURRENT OF LIFE

ORIGIN AND DEVELOPMENT OF CHARACTERISTICS

York County, Pennsylvania, bordering on the west bank of the Susquehanna River and east-centrally upon the Mason and Dixon Line, has as its centrally located county seat the important inland city, York. Southwesterly, less than thirty miles from York, lies historic Gettysburg. Somewhat nearer, on the Susquehanna, northwesterly, lies Pennsylvania's State Capital, Harrisburg; and eighty-five miles due eastward lies Philadelphia. This limited region is, essentially, the stage of his immediate forbears and the one upon which the life story of Edgar Fahs Smith began, near York, flowed, waxed and nobly ended, in Philadelphia. His enactments upon other stages were but interludes.

Ancestrally, temperamentally, habitually, Dr. Smith genu-


SMITH

inely and luminously reflected, in self and in life, Yorkish Moravians, central Pennsylvanian Covenanters and Philadelphian Quakers, in their quiet, sturdy, conscientious and constructive virtues. His genius was no stroke of aberrant biologic lightning. In him was an admirable culmination of his natural selection, and of his existence in the habitat wherein he breathed that historic, rurally urban and urbanly rural, atmosphere ideally suited to his biologic self.

The racial, political and historical atmosphere of Philadelphia, and Gettysburg are too well known to call for special comment here, but it is not so widely known that York was the first permanent settlement founded, by the Penn Proprietors, west of the Susquehanna (in 1741) ; that the first settlers were mainly German refugees of the Reformation, with some English and Scotch-Irish; that York, as a pioneer settlement, so flourished that it became our young nation's capital, in 1777-1778, when the British troops threatened Philadelphia; that there the Congress passed the Articles of Confederation, there came Lafayette and Steuben as knights-errant in the American cause, there came the treasure lent by France, there Benjamin Franklin's press issued the $10,000,000 of Continental money, and there came Gordon's Confederate troops at the Gettysburg battle.

At his grist-mill by the mill-stream, in West Manchester township near York, in the years just preceding the American Civil War lived a poor miller, Gibson Smith, a son of the region, upright and respected, though without church affiliation, probably of Scotch-Irish strain, and his native goodwife, Susan Elizabeth Fahs (Smith), a devout Moravian, probably of German strain. The only language of the household was English. To this typical York couple, came, May 23, 1854, when the father was aged thirty-two years, their first child, a son, Edgar Fahs Smith, herein memorialized.

To these parents was later born one other child, Allen John Smith (1863-1926). The younger brother displayed, by his life, the same sound and admirable general characteristics as his elder and more famed brother. He became a physician and an eminent author and professor in pathology in the University of Pennsylvania. Gibson Smith soon moved his family into

York, became a grain, wood and coal merchant there, grew with the town, was always substantial, became known as "a man of means," never wealthy, died suddenly, of pneumonia, in middle age, leaving a sizable estate. It was under such modest but comfortable circumstances, and with excellent health, that Edgar Fahs Smith began and lived his life. There is no record of privation, hardship, tragedy or hectic drama; or of super-struggle against bad health, bad luck or adversity. Neither is there record of sudden and thrilling emotion, accession or loss of wealth, position or influence. The current of his life's events flowed quietly, smoothly, deeply, in normal channels, as human life may flow—with no excesses of conduct, joys, sorrows, successes, failures—a model of a good human life-stream—beginning near the millside, gaining volume gradually, surely; no narrows, no floods, no rapids, waxing progressively to metropolitan and national importance, and merging finally into the ocean of historic goodworks. Like all life-streams, it had, of course, its waves, but none was tempestuous.

The young Smith grew as a well-trained inland town-boy, guided strictly, rather sternly, by his father; religiously, sweetly, preceptorially, by his mother; uprightly by both. To such training he was precisely adapted. He did well in his early home and private-school lessons. At the age of nine the horror of Gettysburg thrust itself upon him; and he grew to adolescence and manhood in the North's most active region of postbellum war memorialization—where, indeed, that is still active, seventy-two years after the great battle.

In 1785 there was founded in York, the York County Academy, which became highly reputed in the community as a day-school for precollege studies, with emphasis laid upon classical Greek and Latin. After the completion of his early preacademy studies in the local private school and at his mother's knee (she heard him recite his school-boy lessons; insisted upon perfection therein; and devoutly instructed him in the Moravian virtues), the Gibson Smiths sent their son Edgar to the York County Academy for college preparation in 1867; and these studies occupied the lad until their completion in 1872. In the Academy he began to find himself; our record of him shows that there

he began to exhibit those ideas and qualities which ever characterized him. He became so proficient in Latin that for two years he taught it in the Academy, as a schoolboy, to the younger boys. There he cultivated a fondness for the classics and the humanities which he never lost. Of this period in his life his brother Allen writes:

"He would have been successful under any conditions—his natural bent toward reasonable precision and method guaranteed that; but the measure of his success he owes in particular to two persons—his mother and his old teacher, Dr. George W. Ruby, principal of York County Academy for nearly a generation. Night by night, in the light of an old-fashioned fat lamp, his mother had the boy work out and recite to her all his lessons for the following day, and no half acquaintance with the tasks was acknowledged or allowed. The innate aim for thoroughness was formed into a reality at his mother's side, and what power of analysis and memory nature gave him was educated into a habit of easy practice. . . . It was while attending the York Academy that in association with a coterie of kindred spirits he established and for several years was in turn, or all at one time, editor, contributor, compositor, pressman, and financial agent of a youthful publication known as *'Our Effort'*—a short-lived effort, dying promptly when the boys who built it up passed from the old school into college. He, in this experience learned sufficiently the trade of printing to have been repeatedly accepted in holidays to do substitution and special work as compositor or proofreader in the office of one of the important publishing houses of the town; and his claim to be a typothete fits well the man who has sat in Franklin's old chair in the Philosophical Society, and worked as he has for the glorification of the University that Franklin founded."

A complete file of *"Our Effort"* is to be seen among the memorabilia; and is remarkable for the youth of seventeen years. The *Effort* file shows him even then clearly setting his course for his full life's effort; and he never deviated from the there announced purpose of "forwarding of science." The following excerpts from the first number illustrate his practicality, his style, his aim.

OUR EFFORT

Vol. I York, Pa., July, 1871. No. I

OUR EFFORT

is printed every month, at the low rate of 50 cents a year, in advance.
No subscriptions will be received for less than a period of six months, and none can be withdrawn before all the arrearages are canceled. A failure to notify the printer of a discontinuance at the end of the subscribed term will be regarded as a new subscription.

All letters should be addressed to

Edgar F. Smith
P. O. Box 431,
York, Pa.

The Formation of the Earth (Title of first article)

Editorial in first number July 1871.

It is with great diffidence, that we present to you, for the first time "OUR EFFORT" which is INDEED an effort, for it has required a GREAT amount of thought upon the part of the proprietors, whether or not, it would be advisable to publish a magazine edited by BOYS. The trial has finally been made, and we beg of you, kind reader, not to turn away muttering, "Pshaw, what can boys do," but let your charitable feelings predominate, and assist us with your small subscription of fifty cents. We do not expect to compete with the productions of the learned men of the times, which are circulating in the most enlightened portions of the globe; but in our humble position aid as much as possible in the forwarding of science, the love of which has incited us to such an important undertaking, and which has, does and ever will contribute to the happiness of man.

And now we sincerely hope that you will "think before you act," and after a careful consideration, make us happy with the

announcement that you have concluded to assist BOYS. With this short note, we bid you good-day.

One finds from the record of Dr. Smith that the boy who, aged seventeen years, was a teacher of classics, a devotee of science and a writer on science and history so continued throughout life. The *Effort* shows that in science, chemistry and medicine beckoned him. Actually his maturer goal was medicine via the chemical route. In the end, it befell that chemistry held him; but he never lost his active interest in medicine; and as Provost of the University of Pennsylvania he labored earnestly and fruitfully in the development of undergraduate medical education; in instituting graduate medical education; and in the expansion of medical research.

His studies in the York County Academy nearing their completion, in 1872 he planned presently to enter Yale. However, he accompanied to Gettysburg a chum who was applying for admission to Pennsylvania College (since 1917 officially known as Gettysburg College) located there. This chance visit to Gettysburg profoundly influenced the future course of his life. The College authorities examined him; and found that the youth from the York County Academy was so exceptionally advanced in his studies that he rated as admissible to the College as a Junior student. Edgar Smith embraced this opportunity; and entered Pennsylvania College in 1872 as a Junior. His curriculum included Greek and Latin and presumably some other subjects, but majored in chemistry and mineralogy under the late Dr. Samuel Philip Sadtler, a graduate of Pennsylvania College, and the, then, Professor of Chemistry there. In 1874 Pennsylvania College conferred the degree of Bachelor of Science upon this special student. While studying at Gettysburg, a warm personal and scientific friendship developed between Dr. Sadtler and Edgar Smith; Dr. Sadtler admired young Smith and encouraged him in the idea of making chemistry a life-goal—since he considered that an excellent goal, and his young student excellently suited for it. He also advised the youth and his parents that further studies were needed; and that they could best occur in the University of Göttingen, Hanover, Germany, under the famous Professor Frederick

Wöhler. The record discloses that Gibson Smith, with only a minimal education, had become a comparative local success; but, withal, he rather shrank from the expense and was dubious of the necessity of European study. However, he was a wise, broad and farseeing man (Dr. Smith in his later life often expressed his admiration for his father and for his father's prescience, and said, "if only I had a mind as good as that of my father!"); and, becoming convinced by Dr. Sadtler, consented. Meanwhile, in Gettysburg, student Edgar Smith had met town-maiden Margie Gruel. By the time his family had decided that Edgar should go to Göttingen, Margie and Edgar had decided upon their marriage as soon as Edgar returned. Both purposes became fulfilled with high success, as the sequel shows.

Accordingly, in 1874, "Edgarium Fahs Smith" matriculated at Göttingen as a candidate in chemistry; and in 1876 the University awarded him its "Philosophiae Doctorem et Artium Liberalium Magistrum" diploma; which diploma was renewed by the University a half century later, 1926, as a signal mark of honorary recognition of his "fifty years of science as a teacher and investigator."

Dr. Sadtler became, in 1874, Assistant Professor of Chemistry in the University of Pennsylvania, advancing in 1887 to the Professorship of Organic and Industrial Chemistry and to the headship of the department. Dr. Smith, who in 1888 had become Professor of Analytical Chemistry, became Professor of Chemistry and head of the department in 1891, the year of Dr. Sadtler's retirement, and the fine Sadtler-Smith friendship and fellowship became thus climaxed.

Edgar Smith entered Göttingen with no practical knowledge of the German language. Within the two years of his stay in Göttingen it was necessary for him to acquire his German; and to qualify for his examinations. He never became a thoroughly fluent German speaker; but he acquired and retained a good conversational knowledge of it; became very facile in German chemical composition and transcription with English; and his Göttingen examiners complimented him upon his excellent examinations in Latin chemical composition and exposition.

He always enjoyed relating his Göttingen experiences to

intimates; and particularly two experiences concerning his examinations. The first one runs about as follows. He was worried about his progress examination because a German student whom he considered even better prepared than himself had recently failed. He sought advice and was counseled to prepare himself well upon questions concerning platinum ores which Professor Wöhler was "sure to ask." He therefore prepared himself perfectly as advised. In the examination, what with his stage-fright, what with his halting German, and, perhaps, what with imperfect preparedness, he at first felt himself to be submerged. Eventually, however, came the expected "ores of platinum" question. Whereupon, in fluent, perfect Hanoverian German, he astonished his examiners by his sudden German transformation and by his technically complete and flawless answers—for the reason that he had memorized and practiced the answer, verbatim, in Wöhler's own German, and so thoroughly that even his stage-fright gave way to stage-assurance. Later, when Wöhler notified Smith that his examination had been rated successful, the Professor stated that the transformation which occurred in it had puzzled the examiners, and he requested Smith's explanation. The explanation was frankly given, with name of the previous, unsuccessful student. Whereupon Wöhler laughed heartily; told him that it was a foolish thing to do; that the German student had failed because of previous offensive conduct; that it had been decided in advance to "pluck" him; that any student whose work in the laboratory had been done faithfully and who had conducted himself properly need have no fear of the examination.

The other experience concerned his doctorate examination. In the customary, required, top-hat and formal full-dress attire, he reported to his examiners to "defend" his doctorate thesis. The "defense" began in German, and was rather grim and dismal. However a Latin autobiographic sketch was also required, and necessitated defense of his Latin rendition. Here the days with stern old Dr. Ruby and his boys at the York County Academy came to the rescue. He did so strikingly well with his Latinity and classical quotations as, once more, to astonish and enthuse his thirty examiners, who approved him and dis-

missed him with praise—smiles replacing their grimness, and joy replacing his depression.

As the sequel now shows, the American Centennial Year, 1876, was of greater moment to Dr. Smith, to the University of Pennsylvania and to American science than, then, any one concerned could have foreseen. In that year he received his Göttingen doctorate, returned to the United States, became an instructor in chemistry in the University of Pennsylvania, married Margie A. Gruel, and thus began his real life—in the manly, vocational and service senses. It were idle here to remind of the importance of Göttingen in this life-story, of the importance to them of the long, fruitful mutuality between Dr. Smith and the University of Pennsylvania, or of Dr. Smith's public superservice.

But his story would lack an essential element, did we not here dwell, just enough, upon Dr. Smith's marriage in his real "commencement" year, 1876. That marriage joined him to a mate who insured that his whole life of service, fifty-two years beginning in that year-of-auspice, should be domestically serene, and free from worldly cares beyond his worldly service-field. Mrs. Smith not only made for Dr. Smith that happy homelife so essential to his personality and best success, but also attended to all of those matters outside the home, and outside of his service-field, which were essential to Dr. Smith's work, welfare and serenity. One may not say that an unhappy home, or lack of such loving and capable guardianship, would have blighted Dr. Smith's progress, for that is beyond human ken; but one may say that his progress was so complementarily facilitated by his mate as to make the progress a certainty. She has survived him; and from her unaffluent means has continued her care of him in life by her care for his purposes and memory in death, by endowing the Edgar Fahs Smith Collection of Chemical Memorabilia, thus insuring the permanence, indefinite expansion and general service which he began for the benign cause of historical chemistry, and for which he so ably labored as to become that cause's honored American Nestor.

This is an appropriate place in which to speak of that phase of Dr. Smith's character which has to do with money, because

in that phase he thoroughly needed Mrs. Smith's wise oversight. He always had sufficient money to satisfy his personal needs—not because he ever was wealthy, but because he was never too needy for his simple mode of life. Luxuries never appealed to him—would have disturbed him. His modest means cared for his modest requirements; and beyond that he was quite indifferent to money for himself.

He longed for money only for the benefit of others, particularly for the University of Pennsylvania. He turned back to the benefit of the University by his personal expenditures for it, the total of perhaps $50,000 of his administrative salary received from the University during his years of Provostship. His method was himself to pay for anything which he believed the University urgently to need, for which his own funds sufficed, and for which the University Trustees could not, or would not, provide. However, he was also openhanded toward any quarter of need which had a special appeal to him—so much so that Mrs. Smith's brake, anon, became quite necessary to prevent a threatened domestic financial skid due to this indifference or carelessness in their money affairs. She encouraged and indulged Edgar's benign, and lovable, financial imprudence; doubtless took secret pride in it; but she applied the brake when the speed grew risky. He obeyed her simply, and probably acted with the secure and comfortable feeling that she was watching and would halt him at the right moment. Such an arrangement was precisely suited to his selflessness in money matters.

Various of his research results possessed large potential commercial applications and profits; but that did not cause him to patent them or to give such considerations more than passing notice. Notable here were his researches with tungsten, which forecast the successful electric incandescent lamps of today—a huge industry. Had his been the gain from that industry, doubtless he would have enjoyed applying that gain to purposes dear to him; but the idea of pursuit of money for himself, and the deflection from loved pursuits which distasteful money pursuit would have necessitated, so irked him that he would have none of it. We find no patent or commercial record of him in our

Sources; we do have a record that the profitable potentialities of his electrochemical research genius had so impressed certain substantial industrialists that upon his University retirement they tried to lure his services by a $25,000 per annum salary bait. This was a sincere and attractive offer for one whose remunerations had always been much more modest; but it was promptly declined, because he longed not at all for money, and because he did want to continue his researches in pure and historical chemistry in his own philosopher's way.

Dr. Smith's simplicity in money matters has illustration by many remembered and amusing incidents. Let us repeat just one. It happened upon a rare occasion that there came to Dr. Smith what to him was the large free surplus of about $2000. He paid no attention to it, however. Its safety and unearning worried Mrs. Smith, who finally induced the Doctor to agree that it should be deposited in a certain bank's savings-account; but he made the reservation that she must attend to the opening of the account. This duty, quite in the customary channel, Mrs. Smith performed. The banker impressed upon Mrs. Smith the necessity for the bank to keep Dr. Smith's signature on file; but agreed, that since attention to such a matter would irk Dr. Smith, that Dr. Smith might sign a card and send it to the bank by post. Mrs. Smith duly instructed her husband, who promised to obey; but imagine Mrs. Smith's astonishment when she received a letter from the banker complaining that Dr. Smith had mailed his visiting card to the banker, who protested that the same would not suffice.

Our "Introduction" has served to present the high points concerning Dr. Smith; consultation of the listed details of our "Biographic Sources" provides, by categories, a conspectus of his astonishingly large, varied and important achievements and memorabilia; we have been at pains to show the nature of his ancestral background, of his early training and environment; of his fundamental professional preparation; and of his serenely simple home-life and mental habits. Who and what he was and what his works, have been made apparent; but certain commentaries are still needed to complete the picture sufficiently for the herein purposes.

THE MAN'S WORKS

From what we have learned, it seems clear that with Edgar Fahs Smith and his works nothing of importance appeared by accident. He and his works liken to a mathematically necessary product of the factors which were known when he early emerges as a young man of the defined lineage, home influence, native environment, school-college-university training, mating and initial vocational, service location. While the product of those definite factors could not have been written in 1876, yet after the close of his long life, it is retrospectively plain that in the fifty-two years of his life extending beyond that year, what happened is just what could have been expected. While anyone's life and works may be considered as products of similar factors, his life is rare, perhaps unique, in that it is a life of world-eminence wherein the factors are clear at age twenty-two; and wherein the accidental plays, if any, an insignificant rôle. This conclusion becomes confirmed if one examines into all of the available biographic material. One finds nothing aberrant. Every fact fits smoothly into the pattern.

To the world broadly, the memory of Dr. Smith is that of an eminent American chemist and professor of chemistry, and of a distinguished head of a great and venerable University—more specifically, that of a pathfinding researcher in electro-chemistry, of a researcher in the chemistry of rarer elements, of the leading pioneer historian of American chemistry, and of a Provost of the University of Pennsylvania.

To the narrower world (yet a large one) of those blessed by intimacy with him, his qualities of sheer goodness remain so bright in memory that by a phenomenon of mental irradiation those qualities tend to blur the broader field of the world's retina of memory.

In particularizing upon the works of Dr. Smith one soon finds that the particulars in world-focus are so largely influenced by those of intimate-focus that due understanding of the former necessitates adequate consideration of the latter. Let us, therefore, proceed with a particularization in which, at desire, personal qualities as well as personal works may appear.

AS A RESEARCH WORKER AND CONTRIBUTOR IN PURE CHEMISTRY AND IN AMERICAN CHEMICAL HISTORY

The general domain of this most important section of Dr. Smith's memorial has been covered flawlessly by Dr. Marston Taylor Bogert in a masterly Memorial-Service address by him (1928).

Members of the staff of the Department of Chemistry of the University of Pennsylvania have provided for an annual lecture, by some specially invited expert, in any selected field of chemistry. To honor the memory of Dr. Smith, this annual lecture is named, "The Edgar Fahs Smith Memorial Lecture." In 1935 the lecturer was Dr. Colin G. Fink of Columbia University. Dr. Fink presented an excellent survey of Dr. Smith's contributions to electrochemistry. In the belief that other treatment would yield a less valuable result there is next presented, largely verbatim, an appropriate and slightly edited selection from Dr. Bogert's address, amplified somewhat by a quotation from Dr. Fink's lecture. Bibliographic references are omitted because they appear in our section "Biographic Sources."

Dr. Smith's chemical career may be said to fall roughly into the following periods, arranging them in chronological sequence and according to the fields of major activity at the time:

I. Organic chemistry
II. Inorganic, analytical, and electrochemistry
III. Historical chemistry

I. ORGANIC CHEMISTRY

At the University of Göttingen his research work for the doctorate had consisted in a study of "the trisubstituted benzol compounds and the action of chlorine upon benzyl trichloride," in the course of which he investigated the effect of exhaustive chlorination of benzotrichloride, assisted by intermittent exposure to direct sunlight, and isolated a new chloride of carbon, to which he assigned the formula $C_{21}Cl_{26}$ (m.p. 152°–153°), which was reduced by zinc and sulphuric acid to another new

chloride, $C_{22}HCl_{25}$ (m.p. 102°), or by sodium amalgam to various unidentified products.

Heated with aniline at 180°, it yielded a new crystalline and very easily soluble base, the constitution of which was not determined.

After standing for twelve years, the m.p. of this $C_{21}Cl_{26}$ compound fell to 101°, although its percentage of carbon and hydrogen remained approximately the same. (Smith and Keller)

Salicylic acid was one of the organic compounds under investigation in the Göttingen laboratory during Dr. Smith's student days there, so that it is not surprising that we find him directing his own attention next to this interesting acid and its isomers, and in 1877 he published a paper "On a dichlorsalicylic acid and on monochlorsalicylic acid," in which he observed the formation of a dichloro (m.p. 212°–214°) and a monochloro (m.p. 172°) salicylic acid when chlorine was passed into an acetic acid solution of salicylic acid. Salts and other derivatives were prepared of both of these chloro acids.

This work was an attempt to duplicate the results obtained by Rogers (*Inaug. Diss.*, University of Göttingen, 1875), who, by similar treatment of salicylic acid, secured a dichloro acid of m.p. 224°.

Smith's acids were proven subsequently, by other investigators, to be the 3, 5-dichloro and 5-monochloro derivatives. In association with Hoskinson he showed that this same 5-chlorosalicylic acid (m.p. 172°), when treated with bromine in alcoholic solution, gave a bromochlorosalicylic acid (m.p. 229°), from which various salts and esters were prepared. He found, further, that the corresponding bromosalicylic acid, when iodinated in alcoholic solution by the method of Weselsky, yielded an iodobromosalicylic acid (m.p. 208°–209°), from which he also prepared certain salts and the methyl ester.

With Knerr he proved that 5-chlorosalicylic acid could be converted into the iodochlorosalicylic acid by the action of iodine in alcoholic solution, in the presence of oxide of mercury; but that, in the absence of the latter the product was the iodochlorobenzoic acid. Many salts of the iodochlorosalicylic acid were described.

As early as 1880 he effected a synthesis of salicylic acid from benzoic acid by heating copper benzoate and water together in a sealed tube for three hours at 180°, or benzoic acid, water, and an ammoniacal solution of cupric oxide at 220°; although the yields in both cases were very low.

The delicacy of the salicylic acid reaction for ferric iron was tested by him by adding an alcoholic solution of the acid to an aqueous one of ferric chloride and it was found that 1/32,000th of a mg. of iron could be detected in this way. With monochloro (m.p. 172°), or dibromosalicylic acid (m.p. 218°), the test was less delicate.

Smith and Knerr discovered that when nitrous anhydride was passed into an ethereal solution of oil of wintergreen, the 3- and 5-nitro derivatives of methyl salicylate were produced and could be separated easily by their different solubility in ether.

It was known already that the action of fuming nitric acid upon 5-chlorosalicylic acid gave a nitrochlorosalicylic acid (m.p. 162°–163°) and 4-chloro-2, 6-dinitrophenol (m.p. 78°–80°) when Smith and Miss Peirce showed that there was formed also in this reaction another chlorodinitrophenol, subsequently proven by others to be the 6-chloro-2, 4-dinitroisomer (m.p. 110°–111°). Smith noted that the 4-chloro-2, 6-dinitrophenol, which differs from picric acid only in having a chlorine in place of one of the nitro groups of the latter, combined directly with aniline and various other bases to beautiful crystalline compounds apparently in the same way and of the same character as the analogous picrates. Ten years later he extended this reaction to other aromatic bases and to anthracene, and also uncovered the interesting fact that dichloronitrophenol does not form similar compounds with aromatic bases or with anthracene, from which he drew the conclusion that at least two nitro groups must be present on the nucleus of the phenol to obtain such products.

Having studied salicylic acid and its derivatives, it was quite natural that he should turn his thoughts also to the isomeric *m*- and *p*-hydroxy benzoic acids, and in 1888 and 1889 he reported the results of his investigations of the actions of the gases from arsenic trioxide and nitric acid upon an ether solution of the ethyl ester of each of these two acids. In the case of the

meta acid the products were the 4-nitro ester (m.p. of the free acid, 230°), a trinitro derivative and unidentified substances. From the *para*-hydroxy ester, he obtained a nitro ester carrying its nitro group *ortho* to the hydroxyl, and from this he prepared the free acid (m.p. 184°–185°), certain salts and the amide.

After 1889, his interest in the organic field seems to have waned, as he became more and more engrossed in the problems of inorganic, analytical, and electrochemistry, and it was only infrequently thereafter that he returned to it, to direct an occasional dissertation of some graduate student wishing to pursue his studies in that direction, like that of Seal (1895) on "The action of acid amides upon benzoin," or of Ryan (1897) on "Derivatives of pyroracemic acid"; or a brief research, as that with Hanna entitled, "Observations on derivatives of aconitic acid." In pursuing his researches in the electrochemical field, organic compounds were occasionally selected for the experiments, as in the application of the electric current to accomplish the oxidation of succinic acid (Clarke and Smith), or of toluene (Merzbacher and Smith), its action upon benzoin and benzil (J. H. James), "The influence of substituents on the electric conductivity of benzoic acid" (A. Tingle), and "An electrolytic study of pyroracemic acid (G. W. Rockwell). Finally, organic compounds were tried as precipitants for the separation of inorganic mixtures as, for example, "The action of salicylic acid upon the metallic acids" (J. H. Müller), and the use of "Aromatic bases as precipitants for rare earth metals" (Alice McM. Jefferson).

II. INORGANIC, ANALYTICAL, AND ELECTRO-CHEMISTRY

It was to these fields that he devoted the major part of his fifty-two years of active research and an immense amount of valuable work was accomplished.

A. Electrochemistry

Perhaps his most important contributions were those he made to electrochemistry, a domain in which he was a pioneer and soon became a recognized leader of international reputation.

In the hands of this master craftsman, the electric current became a tool of undreamed-of usefulness and possibilities, opening up wholly new methods of analysis, separation and determination. About half of all the research papers he published were based upon new applications of the electric current. His introduction of the rotating anode together with the employment of currents of high amperage and high voltage, marked a new epoch in the development of electroanalysis. His books on electrochemistry quickly became and have since remained the standard texts in this country, while the Harrison Laboratory was soon known throughout the world for its leadership in this branch of chemistry.

Dr. Smith's first papers on electroanalysis appeared in 1879 in the *Proceedings of the American Philosophical Society* and in the *American Journal*. Other papers on the same topic followed at frequent intervals from that time on, but it was not until 1901 that a radical change in Dr. Smith's method of electroanalysis was introduced. In that year while experimenting on the separation of tungsten from molybdenum Dr. Smith came upon the idea of rotating the anode. He discovered that "by causing the anode to rotate at a high speed, greater current intensity and higher voltage might be applied with an attending, more rapid precipitation of the respective metals."

Then followed the detailed experiments of F. F. Exner, a student working under Dr. Smith's direction. Exner's Ph.D. thesis was published in June, 1903, and the results recorded "were of such remarkable character that many chemists considered the field of electroanalysis to have been truly revolutionized by them."

Although agitation of the electrolyte by some means or other had been suggested by others besides Dr. Smith, it was he who first suggested the combination of a rotating anode and high cathode current densities. Determinations which had previous to 1901, with stationary electrodes and low current densities, taken two to four hours and more, were now through the findings of Smith and Exner reduced to 5 or 10 minutes. Furthermore, the quantities that could be accurately determined were more than threefold the quantities by the older methods.

If we glance through the numerous records of Dr. Smith and his students, we find that copper determinations were now made in 4 minutes; complete precipitation of cadmium in 10 minutes; bismuth, lead, silver, zinc, nickel, cobalt, manganese, iron, chromium, uranium, thallium, indium, platinum, palladium, rhodium, molybdenum, gold, tin, antimony, tellurium, arsenic—almost the entire periodic table of elements all precipitated, either as metal or as specific compound, in small fractions of an hour instead of several hours. But this is not all—separations of one metal from another could be carried out more readily and more exactly with the use of the rotating anode—a number of the separations not being even attempted previous to Dr. Smith.

In fine, the researches of Dr. Smith, 1901-1903, laid the foundations of all that has followed, and led to our clearer interpretation of the steps in the electrodeposition of metals.

B. Atomic Weights

The results obtained in the study of numerous inorganic compounds by the older methods and by these newly developed applications of the electric current, led to the discovery of new processes of analytical separation and to the preparation of many elements and compounds in exceptional purity.

This knowledge and these highly purified products were availed of by Dr. Smith and his co-workers in new determinations of the atomic weights of the elements, those fundamental units of our science. New ratios were established with the most painstaking care and accuracy, for comparison with those already in the literature.

For example, Debray had shown, in 1852, that in a current of dry hydrogen chloride, molybdic acid could be completely volatilized as the dihydroxychloride. In the Harrison Laboratory this method was used to expel the molybdic acid from sodium molybdate, leaving only sodium chloride, and also as a means of separating molybdenum from tungsten. This suggested quite obviously a study of the behavior of other metallic oxides when treated similarly, with the consequence that many proved to be volatile not only in dry hydrogen chloride but also in other gaseous hydrogen halides. Such a complete elimination

of certain of the elementary components of a pure compound provided another new way of arriving at atomic weight ratios.

In addition to this method and the electrolytic one of determining these atomic weight ratios, others were invented to meet the needs of special cases.

The elements included in these studies were Ag, Cd, Hg, Sc, V, Nb (Cb), Ta, N, As, Sb, Mo, W, Se, F, Cl, Br, B and Pd, a total of 18, or 20% of all now known to chemistry.

As the methods employed for these important determinations illustrate admirably the type of work then being conducted in the Harrison Laboratory, it will be instructive to consider them for a few moments in somewhat more detail, to appreciate fully the resourcefulness and skill of their directing genius.

(a) *Electrolytic Methods*

Silver is so beautifully and so completely precipitated by the electric current that varying amounts of silver nitrate were electrolyzed in the presence of potassium cyanide, and the precipitated silver weighed. Then silver acetate and silver benzoate were substituted in turn for the nitrate. The general average of these numerous determinations as carried out by Hardin gave the atomic weight of silver as 107.928. The accepted figure today is 107.880.

Cadmium.—In 1892, Lorimer and Smith dissolved cadmium oxide in potassium cyanide, electrolyzed the solution, and weighed the metallic cadmium separated. The results indicated an atomic weight for cadmium of 112.055.

Four years later, Hardin and Smith conducted similar experiments substituting anhydrous cadmium chloride and cadmium bromide for the oxide, and obtained a mean atomic weight of 112.045.

The average of all these determinations gave cadmium an atomic weight of 112.048. The figure now accepted is 112.41.

Mercury.—Hardin and Smith also electrolyzed mercuric chloride and bromide, in the presence of potassium cyanide, obtaining with the chloride an atomic weight for mercury of 200.006, and with the bromide of 199.883. The electrolysis of mercuric cyanide in platinum dishes gave an atomic weight of

200.071; while the simultaneous precipitation of mercury and silver from a cyanide solution by the same current, gave for mercury the value 199.996. The mean of all these determinations was 199.989. The accepted figure today is 200.61.

Palladium.—The determination of the atomic weight of palladium proved to be an exceptionally difficult task. Keller and Smith electrolyzed an ammoniacal solution of palladammonium chloride, plating out the metal on the silver-coated platinum dishes which served as cathodes. The atomic weight of palladium found in this way was 106.914.

Seven years later Hardin heated diphenyl-palladammonium chloride in a current of hydrogen, and obtained an atomic weight of 107.006 for palladium. Using the corresponding bromide, the figure was 107.036. In another series of experiments, he used ammonium palladium bromide instead, and found the value 107.00.

In 1908, Kemmerer heated palladammonium chloride, in an atmosphere of hydrogen and weighed the residual metallic palladium. The results won pointed to a mean atomic weight for palladium of 106.420. Palladammonium cyanide, similarly treated, yielded the figure 106.458. He also undertook to precipitate silver and palladium by the same current, using as anodes pencils of these metals, planning in this way to compare the weights of the two metals separated upon the cathodes and thus to arrive at a direct ratio between palladium and silver. The failure of the experiments was traced to the presence of palladium still in the solutions.

Later, Shinn precipated metallic palladium from an ammoniacal solution of palladammonium chloride by the addition of ammonium formate and by this method arrived at an atomic weight of 106.709 for palladium.

The atomic weight assigned now to palladium is 106.7. In the course of the reductions in a current of hydrogen, it was discovered that great care was necessary to avoid volatilization of palladium double salts and even of the metal itself; while Dr. Smith believed that the somewhat high results of the electrolytic method were not due to occlusion of hydrogen by the precipitated palladium, but to the presence of varying amounts of

derivatives of quadrivalent palladium in the supposedly pure derivatives of the divalent palladium used for the experiments.

Chlorine and Bromine.—The quantitative determination of anions by the use of a mercury cathode and a rotating silver anode, was developed to such a high degree of accuracy that Goldbaum decided to make use of it for determining the atomic weights of chlorine and bromine by electrolyzing the corresponding sodium halides and weighing the gain in weight of the silver anode. The results showed an atomic weight for chlorine of 35.459, and for bromine of 79.927; as over against the accepted figures of 35.458 and 79.916.

(b) *Methods Based upon the Volatilization of Certain Constituents in a Current of Dry Hydrogen Halide*

Molybdenum.—When normal anhydrous sodium molybdate was heated to about 300° in a current of dry hydrogen chloride, the molybdenum oxide was removed completely, as $MoO_3 \cdot 2HCl$, leaving pure sodium chloride as the residue. By comparing the weight of the residual sodium chloride with that of the initial sodium molybdate, an atomic weight for molybdenum of 96.08 was deduced.

A different method of attack was that of Müller, who succeeded in oxidizing pure molybdenum metal quantitatively to MoO_3, and who thus arrived at an atomic weight of 96.03.

The average of these two sets of experiments is 96.055, in comparison with the official figure of 96.0.

Vanadium.—McAdam, in the course of his work on the vanadates, exposed sodium metavanadate to the action of dry hydrochloric acid at high temperature, which removed the vanadium and left only pure sodium chloride. The atomic weight of vanadium calculated from these experiments was 50.967, while the figure which has been generally adopted is 50.96.

Antimony.—Friend and Smith having discovered that antimony oxide could be removed completely from a mixture by virtue of its volatility in an atmosphere of dry hydrochloric acid, selected potassium antimonyl tartrate as a suitable salt for the establishment of a new ratio for antimony, and an atomic

weight of 120.353 was derived thereby, as over against the present official figure of 121.77.

Nitrogen.—Hibbs ascertained that potassium nitrate could be converted quantitatively into potassium chloride by the action of dry hydrochloric acid at high temperature, and used this fact as the basis of a new way of learning the atomic weight of nitrogen. The value deduced was 14.0118. Another series of experiments with sodium nitrate in place of the potassium salt, gave 14.0116. The general average of these two sets, 14.0117, varies but slightly from the value generally adopted, 14.008.

Arsenic.—Hibbs was also the discoverer of the fact that arsenic oxide could be removed completely from arsenates by the action of dry hydrochloric acid. Subjecting sodium pyroarsenate to this treatment, and weighing the sodium chloride formed, a mean value of 74.915 was found for the atomic weight of arsenic.

Ebaugh conducted a similar series of experiments with silver arsenate and, from the weight of the residual silver chloride, calculated the atomic weight of the arsenic as 75.004. When the silver chloride was reduced to metallic silver, the weights of the latter obtained corresponded to an atomic weight of 74.975. He subjected lead arsenate to the action of dry hydrochloric acid, and also converted it into lead bromide, the first method giving an atomic weight of 75.022, the latter 75.00.

The general average of all these experiments led to the conclusion that the atomic weight of arsenic was not far from 74.983. The figure accepted now is 74.96.

Selenium.—Lenher showed that silver selenite, exposed to dry hydrochloric acid at the proper temperature, lost its selenium completely and left pure silver chloride, from the weight of which the atomic weight of selenium could be calculated. The figure arrived at was 79.325. This figure was checked by reducing the silver chloride to metallic silver, and from the weight of silver obtained, the atomic weight of selenium was deduced as 79.329.

A third method used by Lenher was precipitation of selenium from an aqueous solution of its double ammonium bromide, $(NH_4)_2SeBr_6$, by the action of hydroxylamine. The atomic

weight so obtained was 79.285, making the mean of all these three methods 79.313, in comparison with an accepted value of 79.2.

It is appropriate to recall here that Professor Lenher never lost the inspiration imparted to him by his great teacher or his interest in the chemistry of this particular element, a field in which he soon became a recognized world leader. It is believed that his untimely death was due either largely, or at least in part, to his continuous occupation with poisonous selenium compounds, and that his name should be added to that honor roll of those who have sacrificed their lives in the service of science.

Fluorine.—Sodium fluoride was subjected to the action of hot dry hydrochloric acid gas by McAdam and Smith and from the weight of the residual sodium chloride, the atomic weight of fluorine was deduced as 19.015. The accepted value is 19.00.

(c) *Miscellaneous Methods*

Tantalum.—Chapin and Smith, starting with tantalum pentabromide, hydrolyzed this by the addition of water, and evaporated the solution, adding small amounts of nitric acid towards the close of the evaporation, to eliminate all hydrogen bromide. The hydrated oxide so formed was ignited to Ta_2O_5 and the latter weighed. From the ratio of the weight of the Ta_2O_5 to that of the $TaBr_5$, the atomic weight of tantalum was calculated as 181.80 for the mean of all determinations. The official value is 181.5.

Columbium (Niobium).—Columbium pentachloride was hydrolyzed by Balke and Smith and the columbium oxide weighed. The mean atomic weight so found for columbium was 93.50.

Later, Smith and Van Haagen subjected sodium metacolumbate to the action of sulphur monochloride and were thus able to eliminate the columbic oxide quantitatively, leaving pure sodium chloride as the residue, from the weight of which residue the atomic weight of columbium was deduced as 93.13. The present accepted international value is 93.1.

Tungsten.—This metal and its derivatives have been the subjects of numerous important researches in the Harrison Laboratory. For the establishment of its atomic weight, eight different

methods were used, namely: (1) reduction of the trioxide, (2) oxidation of the metal, (3) weighing the water formed in the reduction of the trioxide, (4) extraction of the water content of barium meta-tungstate, (5) analysis of the hexachloride, (6) analysis of iron tungstate, (7) analysis of silver tungstate, and (8) determination of the water in sodium tungstate. From the figures obtained by these various processes, Dr. Smith was led to conclude that the correct atomic weight for tungsten was not far from 184.05, a figure very close to the present official value of 184.0.

Scandium.—The mean value of the atomic weight of scandium, as determined by Lukens, by calcination of the sulphate to the oxide, was 44.33. The international tables give the preference to the value 45.1.

Boron.—The determination simultaneously of the atomic weight of fluorine and of boron by Smith and Van Haagen was based on the equivalent quantities of a number of different sodium salts formed by the conversion of anhydrous $Na_2B_4O_7$ through treatment with appropriate acids and repeated evaporation with methanol. From these data and the ratio $Na_2B_4O_7$: $2NaF$, the atomic weight of fluorine was calculated as 19.005. The borax used was prepared from pure Na_2CO_3 and H_3BO_3, the latter obtained by saponification of a carefully rectified methyl borate. Complete dehydration of borax proved difficult, but was finally accomplished by prolonged fusion. The methanol used was secured by hydrolysis of distilled methyl oxalate. The direct conversion of borax into sodium fluoride was found to be impracticable, and was attained through the formate. The atomic weight thus deduced for boron was 10.900, which is about 1% lower than the older value, and it is believed that the previous figure was inaccurate because of the retention of some water by the borax glass. The figure accepted today is 10.82.

C. Complex Inorganic Acids

Attracted by the brilliant pioneer work of Wolcott Gibbs, and in consequence of certain observations made in extracting large quantities of tungstic acid from its ores, Dr. Smith determined to investigate certain complex inorganic acids and their deriva-

tives. He succeeded in proving that many of those previously regarded as mixtures of isomorphs were actually distinct chemical individuals, and it was this study which caused him to announce that the great family of naturally occurring silicates was not made up of a series of salts of the several simple silicic acids, but really consisted of the alkali and alkaline earth salts of complex silicic acids, in which metallic oxides and silicic acid jointly formed the complex anion, a view which has been accepted quite generally by chemical mineralogists.

Many wholly new analytical separations and determinations were developed in the course of these studies, and a wealth of new chemical information gathered and carefully recorded.

The first of these studies was carried out by Smith and Exner and concerned itself with ammonium vanadico-phospho-tungstate. This was followed up by Rogers who prepared various ammonium salts of complex anions composed of the following oxides: $P_2O_5.V_2O_5.WO_3$, $P_2O_5.V_2O_3.WO_3$, $P_2O_3.V_2O_3.WO_3$, $As_2O_5.V_2O_5.WO_3$, $As_2O_5.V_2O_3.WO_3$, $As_2O_3.V_2O_3.WO_3$, $P_2O_5.$-$V_2O_5.V_2O_3.WO_3$, $As_2O_5.V_2O_5.V_2O_3.WO_3$, $P_2O_5.As_2O_5.V_2O_3.$-WO_3, and $P_2O_5.As_2O_5.V_2O_5.V_2O_3.WO_3$, with varying amounts of water. The complexity of such salts is obvious.

In later papers, Rogers and Smith prepared and described ammonium silicoso-, titanoso-, zirconoso-, thoroso-, and stannoso-vanadico-phosphotungstates; and also ammonium vanadico- and vanadoso-tungstates.

Paralleling these studies, Balke and Smith, by analogous methods, obtained ammonium and ammonium silver aluminico-tungstates, ammonium potassium and silicon bismuthico-tungstates.

Brubaker added to this list the ammonium manganico-tungstate; ammonium and barium platinoso-tungstates, platinoso-phospho-tungstates, platinoso-arseno-tungstates and platinoso-vanado-tungstates.

Daniels investigated the aluminico-tungstates of copper, barium, mercury and zinc; the aluminico-phospho-tungstates of ammonium, silver, barium and zinc; the aluminico-arseno-tungstates of ammonium, barium and cadmium; the aluminico-antimonio-tungstates of ammonium, silver and barium.

Further contributions were made by Blum by the preparation and investigation of various phospho-vanado-molybdates.

This brief outline will suffice to give some idea of the labyrinthic character of this chemical jungle into which he penetrated so boldly and the difficulties of blazing clear trails therein.

In addition to the elements studied in connection with these complex inorganic acids and atomic weight determinations, he conducted investigations of numerous others, notable among these being such rarer ones as Be, Cs, Ge, In, Rb, Rh, Ru and Tl.

The field of analytical chemistry was enriched by many new methods of separation and determination, as well as by critical studies of methods already in vogue.

III. HISTORICAL CHEMISTRY

Great as have been Dr. Smith's contributions to electrochemistry and to the inorganic chemistry of the rarer elements, they are equalled or surpassed by the service he has rendered as historian of American chemistry, the field to which he devoted the riper years of his rich life.

No one has made so many or so important contributions to this field as he, or shown superior literary gifts in the presentation of his material; and in saying this I am not unappreciative of the admirable publications of Thomas Cooper, Venable, Moore, Stillman, and others. His facile pen and clever characterizations have made these chemists of previous years to live and breathe again, and their noteworthy accomplishments, as well as their foibles and fancies, are described in such a natural and interesting manner that the narrative flows on smoothly and delightfully. Many of the chemists portrayed so charmingly and so vividly by him had been "overshadowed, neglected, forgotten."

ADMINISTRATIVE, EDUCATIONAL, CIVIC, HONORARY, SOCIETIES AND HUMAN ITEMS

There is no occasion to discuss here the truly astonishing *items* of the lists to be found in our adjoined *Biographical Summary* of Edgar Fahs Smith's works and honors. Those lists, being con-

sulted, will speak volumes for themselves. The world always has important service-need and due service-reward for such a man as he; and men who can exemplify his combination of world-service qualities are so rare that employment for them is always at hand.

It were idle to attempt herein, and seriatim, to do justice to Dr. Smith's accomplishments—space alone forbids; one shrinks from inadequacy for his memory; and the cited publications are available to those who will to go further. One may, however, touch upon certain of the high spots; and speak of the determinative human side which underlay Dr. Smith's effectiveness.

All who have written of him have stressed his extraordinary liking for those with whom he came into contact; of their responsive liking for him; and of the fine results flowing from such mutuality. He was no man for backslapping and over-promising. Dignity and conservatism abode with him; but his open, cheery smile and warm hand clasp were also everready, put each one, potent or humble, savant or simple, instantly at ease, autoconvinced him that here was real, spontaneous, kindly and unalloyed friendliness which it would be a pleasure, and privilege to reciprocate in kind—and to do so. It was a feeling akin to that of meeting Santa Claus and having a spontaneous desire to give Santa a present.

Why was this? Because it was no effort for Dr. Smith to be that way. That way was himself. It would have been difficult for him, indeed impossible, save in flashes, to have been any other way. It began with simple piety, a faith in God, and in man as God's chief work. When any one was the other way, Dr. Smith was tolerant, pained, puzzled. He could not understand why any man should be the other way, that surely he must return to the right way—or, if not, it must, like death, humbly be accepted from an inscrutable Providence.

He was a deeply religious man, but with little interest in churchly or creedly matters. It is true that in early life he grew in the Moravian faith, that he was always more of a Moravian than otherwise a sectarian; but it is also true that the United Brethren put their emphasis upon deeds rather than upon beliefs, except the belief in the Highest; and that was

his way. None may think that he wore his piety upon his coat-sleeve. The contrary is the truth. He was shy and retiring concerning himself in any particular. His amiable boldness appeared only for the things which he believed were his to accomplish; but even for them his method was labor and service, rather than controversy. Piety ruled him from within; but outwardly could only be inferred.

Dr. Smith always kept before him, in his office-desk drawer a Bible; a little manual entitled, "Daily Prayers for Moravian Households," (London. Moravian Prayer Union); and the current, yearly, Moravian manual of daily texts. He read daily from each of these books. While he was Vice Provost and Provost of the University of Pennsylvania he conducted, daily at noon, quarter-hour "chapel" services, for those of "his boys" who would attend, in the auditorium of the University's student club-house, Houston Hall, located across the street and lawn from his office. He had the constant and deep conviction that he could do nothing worthy by himself, that it could only occur with God's help. He was daily trying to do something worthy, and so he daily consulted, in seclusion, in his own way, with his Helper; and daylong he tried, still in his own way, to merit that help. There is nothing to show that he felt need for mediation by church or clergy—at least so our Sources tell us; but he had a thoroughgoing respect for the ways of all others in their approach to the Helper.

The University of Pennsylvania stems from the University of Edinburg; and it is due to that history that the University of Pennsylvania has its "Provost." In the years 1898-1911, as Vice Provost, and in the years 1911-1920, as Provost, Dr. Smith served the University administratively as well as academically. His Provostships brought him, inter alia, face to face with money matters. The University had many needs; that meant need for much money; and meant further that he must help to secure it. Perhaps he shrank, but he neither faltered nor failed. Still in his desk-drawer, in the (now) Smith Memorial Room at the University lies his little Moravian manual of daily prayer. Open it, and one finds his markings and notations for his daily chapel services for the students. But, inside the cover, one also finds several irregular slips of paper

with his handwriting upon them, beginning "To the Heavenly Father. Thanks for these." Then follows a memorandum list of many gifts to him for the University and its purposes, by named givers. Dates are not stated but apparently he added a notation of each gift, as it came, to this scraplike little prayer-book list, as his intimate token of thanks to his Helper. To know such revealing things is to know Dr. Smith. Whether the gifts came from Pennsylvania's legislators and executives, or from philanthropic foundations, or from the wealthy or the unwealthy, alive or by devise, they all came by God's help. One can almost see the good Doctor alone in his quiet study, adding a new item upon his little slips of paper, reading his daily prayer and believing his Helper to be there with him.

As Dr. Smith labored in it, and for it, the great University which came to him from Benjamin Franklin's seedling, waxed mightily; when he surrendered its headship to his successor, he had high reason to feel serene; and all who comprise the University, intramurally and extramurally, had high reason for their thankfulness and reverence that Edgar Fahs Smith had so loved and so nourished their academic arbor.

The Provost's home was a small housekeeping apartment in the "Avondale," a few squares from the Harrison Laboratory. Mrs. Smith still resides there. Occasionally there was a maid-servant. Breakfast there was customary. Luncheon was anywhere by the chance of the workday life—mayhap a sandwich which the goodman carried from the home in his pocket—mayhap excellent club luncheons for out-of-town or University-business guests. He was a member of several prominent Philadelphia clubs, so that he could meet there with persons of large affairs and play the rôle of host appropriate to one of his high office. He was a good host; and knew how to make his hospitality enthuse all degrees of his guests, from gourmet to bluestocking. Himself, was abstemious, because he liked substantiality rather than luxury; but he knew, as host, just how to partake to his own best enjoyment and to that of his guests. Dinner was anywhere that was agreeable to Mrs. Smith or necessary in University affairs. This simple home, and mode of life, did not please the alumni, who held Dr. Smith and the University so dearly, and who believed that his comfort and

the dignities concerned called for an official Provost's mansion.

Consequently there was instituted a "drive," resulting in the mansion and in an endowment for its care. This did not please Dr. Smith; and he would not leave his simple apartment home to live in the dignified mansion provided for him—the Alumni could alter his opportunities, but could not alter the Provost.

The Doctor arrived at the Harrison Laboratory about eight o'clock in the morning, and departed at six o'clock in the evening, upon the days when his many duties did not require him to be elsewhere. This was a good example but not copied elsewhere in the University so far as yet reported. However, he did not intend his workday to be an example. He merely wanted to get the most out of his own time. It was no effort for him to do this. It would, to him, have been irksome to have done otherwise.

One of his great joys was "his boys." This was his name for all of his present and former students. His attitude toward them was that of a fond, but not too indulgent, academic father; and students and alumni responded in filial reverence. He greeted hundreds by their first names as soon as he saw their faces—even years after completion of their stays at the University. How he remembered was a mystery to all—including himself. When asked, he would say that he didn't know, that he made no effort to remember, but that remember he did.

He was a fine public speaker, daily addressed groups of his boys, and anywhere, anytime, on any occasion, his addresses were profitable, convincing and enjoyable to his auditors. His facility was a natural gift, which his excellent early training in the classics and the humanites culturally developed, and which his walk in life called into large practice. He probably could have been a success as a dramatic actor or writer. The celebrated Shakespearean scholar, Dr. Horace Howard Furness, characterized him as a "master of concise expression."

He had wide acquaintance with public and political personages and persons. They liked him thoroughly, and had complete confidence in him, as attested by the various important public commissions to which he became appointed. He liked them, as he liked all men; and, patriotically, liked to serve upon special-service "nonpolitical" public commissions. He was a Republican

as befitted a lad from York's Civil War period; but he disliked unreasoning, unholy, contentious, partisanship just as he disliked anything unreasonable, unholy or destructive. During the general time of that trend for the educator in politics which put Woodrow Wilson into New Jersey's Gubernatorial seat, and later into the White House, and put Martin G. Brumbaugh, Philadelphia's respected Superintendent of Schools into the Governorship of the Commonwealth of Pennsylvania, powerful political leaders, his friends, strongly urged Dr. Smith to accept their aid toward the Governorship of Pennsylvania, because they felt that the State needed his type of service. But he would have none of a kind of service which he believed would sever him from those peaceful and fruitful services which he loved, to plunge him into a turmoil which he heartily disliked. This incident is only another illustration of his simple devotion to his own well-chosen way of life.

Dr. Smith's labors and accomplishments loom so hugely, that there must arise the questions: how could he accomplish so much; and, had he no avocation or recreation? If those questions had been propounded to him, his answer to the first would have been, "By God's help"; and his answer to the second would have been "Plenty." Our answers are: to the first question, "He was fit, did not remit, and the very fact that he did it proved that it can be done"; to the second question, "Much that he did, of those doings we have listed, was play to him; and he did various other things, which we have not listed, all of which to him were recreative."

He ever spoke of his collection of memorabilia and of his researches and writings in historical chemistry as "play." The time, energy, study and thought which he gave to his historical collections and writings, could well be regarded as being quite as vocational as his educational and research activities; but to him all of this was avocational and restful.

He was also much interested in collecting early American stipple prints. His collection of stipple prints from plates by the esteemed engraver, David Edwin, is nearly complete, and is regarded by collectors as one of the best extant. It had nothing to do with chemistry; but only to do with art and with

well known personages of the past. This hobby constituted a favorite avocation, and probably an expensive one.

He had an active interest in Freemasonry; and attained to its thirty-third and last degree, which implies that he did much masonic "work." To him, Masonry's ancient, benign, reverent symbolism, discipline and orderliness appealed strongly; and became a recreative retreat.

His real labors were in and for education and research. All else to him was recreative—his activities in societies, conventions and whatnot had that quality for him.

"What!", it is asked, "did he have no downright relaxation, the kind for you and for me?" The answer is, "He did have that kind." He especially enjoyed professional baseball games; and his Kneipe in the companionship of a few select old academic comrades. He was always sturdy, and in his youth he was an ardent baseball player; and an able pitcher in his local sand-lot league. He could tell his good friend, that Nestor of baseball, Connie Mack, a lot about baseball celebrities and statistics; and could listen eagerly to baseball lore new to himself. He often attended professional baseball games when he could find the time during his mature years; and when he got too busy for that, he read the baseball news like any other "fan." He kept so closely in touch with baseball doings, that Rogers, the faithful old diener of the Harrison Laboratory, especially during a "World Series," had to be careful to read the late afternoon papers before going near the beloved Doctor's door at quitting-time, for he was pretty sure to be called upon for the final scores. However, the diener was a "fan" too, which was the good reason for his summons,. diverting alike to Vorstand and Hausmeister.

The Kneipe was, of course, of the sedate German university type, with a modicum of helles or dunkeles; with no smokes for Dr. Smith, who did not use tobacco; and with much random discussion, gentle banter and reminiscences of older chemists and of bygone but dearly remembered University days. Would that that select little group of scholar-boys still in session were; and that you and I might sit with those rare old comrades in that Wolfbräuhaus in the City of Brotherly Love.

The curtain was drawn upon this well-nigh perfect life of right-living and superservice to fellow-man, in the hospital of

the University of Pennsylvania, following a brief pneumonitis, May 3, 1928. As in mind's eye we see it drawn, we think of the words of the sixth Beatitude, "Blessed are the pure in heart, for they shall see God."

BIOGRAPHIC SOURCES

I.

The Edgar Fahs Smith Memorial Collection in the History of Chemistry. This collection, regarded as one of the most notable in the world, was begun early in Dr. Smith's professional life as his favorite, sustained, avocation; and by his fond and unremitting efforts and, for his limited means, heavy cost, had grown to unique excellence before his death. Thereafter it became endowed by Dr. Smith's widow. Located during Dr. Smith's lifetime in his offices in the Harrison Chemical Laboratory of the University of Pennsylvania, it has there, by the joint support of Mrs. Smith, of the University, and of a number of devoted chemical friends, become permanently and conveniently available to the scholarly world; is progressively becoming worthily augmented; and constitutes a singularly appropriate and useful memorial to its eminent founder. He was too modest a man ever to have dreamt of his collection as fated to become a living, permanent and waxing memorial of himself; but such was his affection for historical chemistry, and such his fatherly care and pride for his own collection of chemical memorabilia, that no other memorial to him could have been so suitable. To him it would loom as the enduring, useful, life of a loved child of an otherwise childless, but completely fatherly, man.

In addition to that entirely general, and impersonal, character with which Dr. Smith regarded and constructed his memorial collection, the collection since his death has been continuously enriched with all known or available memorabilia of his own venerated self.

The collection now comprises a cataloged collection of approximately one thousand volumes relating to alchemy and chemistry, dating from the fifteenth century; one thousand related portrait prints and engravings; six hundred related autograph letters and manuscripts; some apparatus used by noted chemists of the past (Joseph Priestley's balance having been one of Dr. Smith's most prized possessions); and memorabilia of the founder. The curator, Miss Eva Armstrong, who was Dr. Smith's private secretary and aide during the last nineteen years of his life, gives her undivided time and attention efficiently to the collection and to the assistance of those who consult it. Her assistance with material for this National Academy of Sciences Biographical Memoir of Dr. Smith is appreciatively acknowledged.

II.

A volume of sixty-two pages, prepared and printed by friends of Dr. Smith, and entitled: *"Memorial Service for Edgar Fahs Smith"*; "The

Provost of the University Presiding"; "William B. Irvine Auditorium, University of Pennsylvania"; "December 4, 1928."

This volume contains: "Biographical Summary"; Invocation by the Reverend Richard Montgomery, reading in part, "that the memory of our beloved Provost, our teacher, may long continue within these walls, to be an incentive to the men who teach, to be an inspiration to the men who study, and that out of his life still may come the influence which tends to Thy honor and glory and the good of mankind"; memorial address by the late Dr. Francis Xavier Dercum, then President of the American Philosophical Society, a scholarly, personal and broad, appreciation of Dr. Smith; memorial address by Dr. Marston Taylor Bogert, a masterly presentation of the personal character and general services of Dr. Smith, and details and analytic critique of the whole of Dr. Smith's chemical labors; memorial address by Dr. Josiah Harmer Penniman, Provost of the University of Pennsylvania, a graceful, felicitous and lettered appreciation by Dr. Smith's former associate in faculty and as Vice Provost, and successor as Provost; and nearly complete, chronologic, bibliographies of Dr. Smith's sixty-five single scientific papers, one hundred eleven coauthorship scientific papers, thirty-five brochures and volumes on American chemical history, thirteen original and translated chemical texts, and eighty-seven doctorate theses in chemistry, inspired, suggested and counseled by Dr. Smith. These bibliographies are presented below.

III.

"The Edgar Fahs Smith Memorial Number" of the *Journal of Chemical Education,* IX, No. 4, April (1932). This number (pp. 607-750) contains various illustrations and one hundred forty-four pages relating directly or collaterally to Dr. Smith. Those pages relating directly to Dr. Smith contain bibliographies like those mentioned under Caption II; and thirty-one pages of biographic and memorial articles; partly reprinted in whole or part from other publications, partly quotations from Mrs. Smith, Dr. Allen J. Smith, and Miss Eva Armstrong, partly editorial by Dr. Lyman C. Newell and Dr. Harrison Hale, and articles by Dr. Walter T. Taggart, Dr. Josiah H. Penniman, Dr. C. A. Browne, Dr. Charles L. Parsons, Dr. Owen L. Shinn, Dr. Allen Rogers, Miss Eva Armstrong, Dr. Neil E. Gordon.

This *Memorial Number* also furnishes a Source list (p. 665) as follows:

"BIOGRAPHICAL ACCOUNTS ON EDGAR FAHS SMITH, APPEARING SINCE 1928

BROWNE, C. A. "Edgar Fahs Smith, 1854-1928," J. CHEM. EDUC., **5**, 656-63 (June, 1928).

TAGGART, WALTER T., "Edgar Fahs Smith," *Science,* **68**, 6-8 (July 6, 1928).

BROWNE, C. A. "Edgar Fahs Smith, 1854-1928," *Isis,* **11**, 375-84 (Dec., 1928).

DERCUM, FRANCIS X., "Edgar Fahs Smith," *Ibid.* MARSTON T. BOGERT. *Ibid.* JOSIAH H. PENNIMAN, "Memorial Service for Edgar Fahs Smith," University of Pennsylvania, December 4, 1928.

"Some Experiences of Dr. Edgar Fahs Smith as a Student under Wöhler." (As recorded by W. MCPHERSON.) J. CHEM. EDUC., 5, 1554-7 (Dec., 1928).

HILDEBRAND, J. H., "Edgar Fahs Smith," *Bull. soc. chim. ind.,* 1929, 22-5.

BOGERT, MARSTON T., "Edgar Fahs Smith—Chemist," *Science,* 69, 557-65 (1929)."

IV.

Another Source is an interesting typewritten brochure, *"Reminiscences of Professor Edgar Fahs Smith,"* unpublished, prepared by Dr. Charles Albert Browne from his private journals, for preservation with the other memorabilia of Dr. Smith. These reminiscences concern many personal meetings, 1920-1927, and conversations between two fellow-spirits in chemical-society and chemical-history activities. They are informal, intimate, frank and engaging; and furnish illuminating, "off-the-record," flashes of Dr. Smith.

V.

Still another, and intimate, Source is the author's many *Personal Contacts, and Correspondence,* with Dr. Smith, his kindred and friends—extending over the past sesquidecade.

DEGREES

IN COURSE: Bachelor of Science—Pennsylvania College (Gettysburg), 1874; Master of Arts, Doctor of Philosophy—University of Göttingen, 1876 (reaffirmed as an honor, 1926).

HONORARY DOCTORATES: *Science*—University of Pennsylvania, 1899; University of Dublin, 1912; Yale University, 1914; Lafayette College, 1924; Wittenberg College, 1927. *Chemistry*—University of Pittsburgh, 1915. *Medicine*—University of Pennsylvania, 1920. *Humanities*—Muhlenberg College, 1911. *Literature*—Swarthmore College, 1918. *Laws*—University of Wisconsin, 1904; University of Pennsylvania, 1906; Pennsylvania College, 1906; Franklin and Marshall College, 1909; Rutgers University, 1911; University of Pittsburgh, 1912; University of North Carolina, 1912; Princeton University, 1913; Wittenberg College, 1914; Brown University, 1914; Allegheny College, 1915; Queen's College (Ontario), 1919; Temple University, 1922; Dickinson College, 1925.

ACADEMIC OFFICES

Instructor in Chemistry, University of Pennsylvania, 1876-81; Professor of Chemistry, Muhlenberg College, 1881-83; Professor of Chemistry, Wittenberg College, 1883-88; Professor of Analytical Chemistry,

University of Pennsylvania, 1888-91; Professor of Chemistry, University of Pennsylvania, 1891-1920; Emeritus Professor of Chemistry, University of Pennsylvania, 1920-28; Vice-Provost, University of Pennsylvania, 1899-1910; Provost, University of Pennsylvania, 1910-20.

ACADEMIC AND LEARNED SOCIETIES

Memberships, etc.: National Academy of Sciences; Society of Chemical Industry; American Philosophical Society (President 1902-08); American Chemical Society (President 1895, 1920-21); American Association for the Advancement of Science; History of Science Society (President 1928); Phi Beta Kappa; Sigma Xi; Phi Kappa Psi.

Honorary Memberships: Philadelphia College of Pharmacy and Science; American Electrochemical Society; American Chemical Society; Société de Chimie Industrielle (France); American Institute of Chemistry; Chemical, Mining, and Metallurgical Society of South Africa.

MEDALS AND DECORATIONS

Elliott Cresson Medal, Franklin Institute (for distinguished contributions to chemistry), 1914; Chandler Medal, Columbia University (for contributions in the field of historical chemistry), 1922; Officer of the Legion of Honor of France (for distinguished services to chemistry), 1923; Priestley Medal, American Chemical Society, 1926.

APPOINTMENTS

Jury of Awards, Chicago Exposition, 1893; United States Assay Commission, 1895, 1901-05; (by President Harding) Board of Technical Advisers, Disarmament Conference and (Chairman), International Committee on Poison Gas and High Explosives; Electoral College for Pennsylvania, 1917, 1925 (President 1925); Commission for Revision of Constitution of Pennsylvania, 1919; College and University Council of the State of Pennsylvania, 1911-20; State Council of Education, 1920-22; Carnegie Institution (Adviser in Chemistry, 1902; Research Associate, 1915, 1918-24); Carnegie Foundation (Trustee 1914-20); Wistar Institute of Anatomy and Biology (President 1911-22).

BIBLIOGRAPHIES

The following abbreviations are used for journals listed several times:
ACJ—American Chemical Journal.
AJS—American Journal of Science.
APSP—American Philosophical Society Proceedings.
ASS—Archivio di Storia della Scienza (Italy).
BdcG—Bericht der deutschen chemischen Gesellschaft (Germany).
CN—Chemical News.
JFI—Journal of the Franklin Institute.
JACS—Journal of the American Chemical Society.

JAAC—Journal of Analytical and Applied Chemistry.
JCE—Journal of Chemical Education.
JIEC—Journal of Industrial and Engineering Chemistry.
NASM—National Academy of Sciences Memoirs.
PM—The Pennsylvania Magazine of History and Biography.
PANS—Proceedings of the Academy of Natural Sciences, Philadelphia.
S—Science.
TAES—Transactions of the American Electrochemical Society.
ZaC—Zeitschrift für anorganische Chemie (Germany).

SCIENTIFIC PAPERS OF EDGAR FAHS SMITH

Ueber trisubstituirte Benzolverbindungen und die Einwirkung von Chlor auf Benzyltrichlorid. Dissertation. Göttingen. 1876. *APSP*. 1877.
Dichlorsalicylic Acid. *APSP*. 1877.
New Chlorine Derivatives of Toluene. *APSP*. 1877.
A New Method for the Decomposition of Chromite. *APSP*. 1877.
Precipitation of Copper by Sodium Carbonate. *APSP*. 1877.
Determination of Phosphorus in Cast Iron. *APSP*. 1878.
A New Chlorinitro-phenol, etc. *APSP*. 1878.
Detection of Iron by Means of Salicylic Acid. *APSP*. 1878.
Ueber eine neue Dichlorsalicylsäure, etc. *BdcG*. 1878.
Beryllium Borate. *APSP*. 1878.
Oxydationsversuche mittelst des Galvanischen Stromes. *BdcG*. 1879.
Analysis of a Calculus found in a Deer. *APSP*. 1879.
Products obtained in the Nitration of m. Chlorsalicylic Acid. *ACJ*. 1879.
A New Base. *ACJ*. 1879.
The Electrolytic Estimation of Cadmium. *APSP*. 1879.
New Results in Electrolysis. *ACJ*. 1879.
The Electrolytic Method as Applied to Cadmium. *ACJ*. 1880.
Synthesis of Salicylic Acid. *ACJ*. 1881.
Corundum and Wavellite. *APSP*. 1882.
Determination of Boracic Acid. *ACJ*. 1882.
Electrolysis of Bismuth Solutions. With N. Wiley Thomas. *ACJ*. 1883.
Minerals from Lehigh County, Pa. *ACJ*. 1883.
Minerals from Berks Co., Pa. With D. B. Brunner. *ACJ*. 1883.
Mineralogical Notes. *ACJ*. 1884.
Electrolysis Molybdenum Solutions. With W. S. Hoskinson. *ACJ*. 1885.
Salicylic Acid Substitution Products. With E. B. Knerr. *ACJ*. 1886.
Substitution Products obtained from Salicylic Acid. With E. B. Knerr. *ACJ*. 1886.
Electrolytic Determinations and Separations. With E. B. Knerr. *ACJ*. 1886.
Electrolysis of Lead Solutions, etc. *APSP*. 1887.

The Electrolytic Method Applied to Iron. *ACJ.* 1888.

Action of the Gas arising from Arsenious Oxide and Nitric Acid upon m- Oxybenzoic Acid. *APSP.* 1888.

Electrolytic Method Applied to Mercury. With L. K. Frankel. *ACJ.* 1889.

Oxidations by Means of the Electric Current. *BdcG.* 1889.

Electrolytic Separation of Cadmium from Zinc. With L. K. Frankel. *ACJ.* 1889.

The Compound $C_{21}Cl_{26}$. With Harry F. Keller. *CN.* 1889.

Derivatives of Mono-chlor.dinitrophenol and Aromatic Bases. *JFI.* 1889.

Vanadium in Caustic Potash. *JFI.* 1889.

Action of the Gases from Arsenious Oxide and Nitric Acid upon p. Oxybenzoic Acid. *JFI.* 1889.

Electrolytic Separations. With L. K. Frankel. *JFI.* 1889.

The Oxidation of Sulphides by Means of the Electric Current. *JFI.* 1890.

Oxydation mittelst des elektrischen Stromes. *BdcG.* 1890.

Action of Hydrogen Sulphide on Metalamines. With Harry F. Keller. *BdcG.* 1890.

Electrolytic Separations. With L. K. Frankel. *ACJ.* 1890.

Electrolytic Separations. With L. K. Frankel. *ACJ.* 1890.

Electrolytic Method applied to Palladium. With H. F. Keller. *ACJ.* 1890.

Electrolysis of Metallic Phosphates. *ACJ.* 1890.

Electrolytic Separations. With L. K. Frankel. *JFI.* 1890.

Electrolysis of Metallic Phosphates. Second Paper. *ACJ.* 1891.

The Decomposition of Chromite by the Electric Current. *ACJ.* 1891.

Electrolytic Separations . With F. Muhr. *ACJ.* 1891.

Electrolytic Method applied to Rhodium. *JAAC.* 1891.

Electrolytic Determination of Mercury. *JAAC.* 1891.

Electrolytic Determination of Gold. *JAAC.* 1891.

The Determination of Tungstic and Molybdic Acids. With R. H. Bradbury. *JAAC.* 1891.

The Electrolysis of the Metallic Sulphocyanides. With L. K. Frankel. *JFI.* 1891.

The Electrolytic Separation of Mercury from Copper. With A. W. McCauley. *JAAC.* 1891.

The Electrolytic Precipitation of Iron. With F. Muhr. *JAAC.* 1891.

Oxidation of the Mineral Chalocite. With D. L. Wallace. *JAAC.* 1891.

Electrolytic Separations. With D. L. Wallace. *JAAC.* 1892.

Ueber die Einwirkung von Molybdan und Wolfram auf Lösungen, etc. *ZaC.* 1892.

Bestimmung des Atomgewichts von Kadmium. With W. S. Lorimer. *ZaC.* 1892.

The Atomic Weight of Palladium. With H. F. Keller. *ACJ.* 1892.

The Electrolytic Separation of Palladium and Platinum from Iridium. *ACJ.* 1892.

Electrolytic Separations. With J. Bird Moyer. *JAAC.* 1893.
Electrolytic Separation of Mercury from Bismuth. With J. B. Moyer. *JAAC.* 1893.
Electrolytic Separation of Copper from Antimony. With D. L. Wallace. *JAAC.* 1893.
Electrolytic Separation of Copper from Bismuth. With J. C. Saltar. *JAAC.* 1893.
Ueber die Einwirkung von Ammoniakgas auf Molybdanychlorid. With Victor Lenher. *ZaC.* 1893.
Einwirkung von Ammoniakgas auf Wolframylchlorid. With O. L. Shinn. *ZaC.* 1893.
Einwirkung der Haloidsäuren in Gasform auf Molybdansäure. With V. Oberholtzer. *ZaC.* 1893.
A Crystalline Chromium Tungstate. With H. L. Dieck. *JACS.* 1893.
Action of Different Gases on Metallic Molybdenum, etc. With V. Oberholtzer. *JACS.* 1893.
Electrolytic Separations. With J. C. Saltar. *JACS.* 1893.
Elektrolytische Trennungen. With J. B. Moyer. *ZaC.* 1893.
Trennung des Kupfers von Wismut. *ZaC.* 1893.
Das Atomgewicht von Molybdan. With P. Maas. *ZaC.* 1893.
Die Trennung des Kupfers von Wismut. *ZaC.* 1893.
Action of the Haloid Acids in Gas Form upon Molybdic Acid. *JACS.* 1893.
Double Bromides of Palladium. With D. L. Wallace. *JACS.* 1894.
Action of Molybdenum Dioxide upon Silver Salts. With O. L. Shinn. *JACS.* 1894.
Elektrochemische Notizen. *ZaC.* 1894.
Electrolytic Separations. *JACS.* 1894.
Electrolytic Separations. With H. C. Spencer. *JACS.* 1894.
Action of Phosphorus Pentachloride upon Molybdenum Trioxide. With G. W. Sargent. *JACS.* 1894.
Doppelbromure von Palladium. With D. L. Wallace. *ZaC.* 1894.
Einwirkung von Molybdandioxyd auf Silbersalze. With O. L. Shinn. *ZaC.* 1894.
Versuche mit Oxyden von Columbium und Tantal. With P. Maas. *ZaC.* 1894.
Verwendung von Quecksilber oxyd bei der Analyse. With P. R. Heyl. *ZaC.* 1894.
Action of Hydrochloric Acid Gas upon Sodium Vanadate. With J. G. Hibbs. *JACS.* 1894.
An Attempt to Prepare Molybdenum Hexachloride. With H. C. Burr. *JACS.* 1894.
Ueber Molybdanamide. With Herman Fleck. *ZaC.* 1894.
Ueber die Einwirkung von Salzsäuregas auf Vanadinsaures Natron. With J. G. Hibbs. *ZaC.* 1894.
Action of Metallic Magnesium upon Manganese Salts. With J. G. Hibbs. *JACS.* 1894.

Ueber das Atomgewicht von Wolfram. *ZaC.* 1895.
Ueber die Specifische Warmes des Metallischen Wolframs. With A. W. Goodspeed. *ZaC.* 1895.
Ueber das Atomgewicht des Wolframs. With E. N. Desi. *ZaC.* 1895.
Ueber das Atomgewicht von Wolfram. With M. Pennington. *ZaC.* 1895.
Action of Haloid Acids upon the Elements of Group V. With F. L. Meyer. *JACS.* 1895.
Uranium Oxynitride. With J. M. Matthews. *JACS.* 1895.
Action of Hydrochloric Acid Gas upon Salts of the Elements of Group V of the Periodic System. With J. G. Hibbs. *JACS.* 1895.
Action of Phosphorus Pentachloride upon the Dioxides of Zirconium and Thorium. With H. B. Harris. *JACS.* 1895.
Electrolytic Determination of Ruthenium. With H. B. Harris. *JACS.* 1895.
Electrolytic Separations. With D. L. Wallace. *JACS.* 1895.
Separation of Iron from Beryllium. With E. A. Atkinson. *JACS.* 1895.
Electrolytic Determination of Mercury. With D. L. Wallace. *JACS.* 1896.
Tungsten Hexabromide. With H. Schaffer. *JACS.* 1896.
Action of Acid Vapors on Metallic Sulphides. With J. Kelly, Jr. *JACS.* 1896.
Separation of Bismuth from Lead. With A. L. Benkert. *JACS.* 1896.
Separation of Manganese from Tungstic Acid. With W. T. Taggart. *JACS.* 1896.
Separation of Vanadium from Arsenic. With C. Field. *JACS.* 1896.
The Electrolytic Determination of Cadmium. With D. L. Wallace. *JACS.* 1897.
Constitution of Arsenopyrite. With F. W. Starke & H. L. Shock. *JACS.* 1897.
Ammonium Selenide. With Victor Lenher. *JACS.* 1898.
Electrolytic Determinations. With D. L. Wallace. *JACS.* 1898.
Action of Sulphur Monochloride upon Minerals. *JACS.* 1898.
Observations on Aconitic Acid. With D. C. Hanna. *JACS.* 1899.
Action of Hypophosphorus Acid on Molybdic Acid. With Clarence Ebaugh. *JACS.* 1899.
Action of Hydrochloric Acid Gas upon Sulphates, Selenates, etc. With R. W. Tunnell. *JACS.* 1899.
Precipitation of Copper by Zinc. With J. C. Shengle. *JACS.* 1899.
Persulphates of Rubidium, Caesium, etc. With A. R. Foster. *JACS.* 1899.
Electrolytic Oxidation of Succinic Acid. With C. H. Clarke. *JACS.* 1899.
Electrolysis of Metallic Phosphate Solution. With H. M. Fernberger. *JACS.* 1899.
Observations upon Tungsten. *JACS.* 1899.
The Electrolytic Oxidation of Toluene. With A. Merzbacher. *JACS.* 1900.

The Separation of Molybdic Acid from Tungstic Acid. With M. J. Rugenberg. *JACS*. 1900.
Experiments on Chalcopyrite. With L. P. Morgan. *JACS*. 1900.
The Atomic Weight of Antimony. With G. Clausen Friend. *JACS*. 1901.
The Electrolytic Separation of Mercury from Copper. With C. R. Spare. *JACS*. 1901.
The Precipitation and Separation of Silver in the Electrolytic Way. With W. H. Fulweiler. *JACS*. 1901.
The Electrolytic Method applied to Uranium. With L. G. Kollock. *JACS*. 1901.
The Electrolysis of Molybdenum Solutions. With L. G. Kollock. *JACS*. 1901.
Alloys made in the Electric Furnace. With L. P. Hamilton. *JACS*. 1901.
The Electrolytic Determination of Molybdenum. *JACS*. 1901.
Ammonium Vanadico Phosphotungstate. With Franz Exner. *JACS*. 1902.
Observation on the Electrolytic Precipitation of Zinc and Copper. *JACS*. 1902.
Use of a Mercury Cathode in Electro-Chemical Analysis. *JACS*. 1903.
Metal Separations in the Electrolytic Way. *JACS*. 1903.
Derivatives of New Complex Inorganic Acids. With Allen Rogers. 2nd paper. *JACS*. 1903.
Derivatives of Complex Inorganic Acids. With Allen Rogers. 3rd paper. *JACS*. 1903.
Derivatives of Complex Inorganic Acids. With A. Rogers. 4th paper. *JACS*. 1903.
Derivatives of Complex Inorganic Acids. With Clarence W. Balke. 5th paper. *JACS*. 1903.
Derivatives of Complex Inorganic Acids. With Allen Rogers. 6th paper. *JACS*. 1903.
Some Observations on Columbium. With R. D. Hall. *APSP*. 1903.
Use of the Rotating Anode in Electroanalysis. *JACS*. 1904.
The Atomic Weight of Tungsten. With Franz Exner. *APSP*. 1904.
Observations on Columbium and Tantalum. *APSP*. 1905.
The Use of the Rotating Anode and Mercury Cathode in Electroanalysis. With L. G. Kollock. *APSP*. 1905.
The Use of the Rotating Anode and Mercury Cathode in Electroanalysis. 2nd paper. *JACS*. 1905.
The Rapid Precipitation of Antimony in the Electrolytic Way. With J. Langness. *JACS*. 1905.
The Effect of Sulphuric Acid on the Deposition of Metals when Using a Mercury Cathode and Rotating Anode. With L. G. Kollock. *APSP*. 1906.
The Use of a Rotating Anode in the Electrolytic Precipitation of Uranium and Molybdenum. With E. T. Wherry. *APSP*. 1906.
The Influence of Sulphuric Acid on the Electrolytic Determination of Metals with the Use of a Rotating Anode and Mercury Cathode. With L. G. Kollock. *JACS*. 1907.

The Electrolysis of Metallic Chloride Solutions with the Use of Rotating Silver Anode and Mercury Cathode. With T. P. McCutcheon. *JACS*. 1907.
The Precipitation of Uranium and Molybdenum with the Use of Rotating Anode. With E. T. Wherry. *JACS*. 1907.
New Results in Electroanalysis. With L. G. Kollock. *APSP*. 1907.
The Cathodic Precipitation of Carbon. With Wm. Blum. *APSP*. 1907.
The Electrolysis of the Halides of the Alkaline Earth Metals. With H. L. Lukens. *JACS*. 1907.
The Determination of Zinc with the Aid of the Mercury Cathode and Rotating Anode. With L. G. Kollock. *TAES*. 1908.
Observations on Columbium. With C. W. Balke. *JACS*. 1908.
Separation of the Alkali Metals in the Electrolytic Way. With J. Goldbaum. *JACS*. 1908.
An Attempt to Separate the Alkaline Earth Metals in the Electrolytic Way. *JACS*. 1909.
Recent Advances in Electrochemical Analysis. *TAES*. 1909.
Electrolytic Separations. With I. H. Buckminster. *JACS*. 1910.
Electrolytic Determination of Chlorine in Hydrochloric Acid with the Use of a Sliver Anode and a Mercury Cathode. *JACS*. 1910.
The Determination of Indium with the Use of a Mercury Cathode. *JACS*. 1910.
Some Berks County Minerals. *PANS*. 1910.
The Atomic Weight of Tantalum. With W. H. Chapin. *JACS*. 1911.
The Action of Hydrofluoric Acid Gas upon Certain Oxides. With W. K. van Haagen. *JACS*. 1911.
The Atomic Weight of Fluorine. With D. J. McAdam. *JACS*. 1912.
Notes on Sodium Columbates. With W. K. van Haagen. *JACS*. 1915.
Atomic Weight of Columbium. With W. K. van Haagen. *JACS*. 1915.
Atomic Weight of Boron. Monograph published by Carnegie Institution of Washington, 1918.
Sodium Tungstates I. *JACS*. 1922.
Sodium Tungstates II. *JACS*. 1924; *CN*. 1924.
Behavior of Organic Bases toward Soluble Tungstates. *APSP*. 1926.
An Interesting Behavior of Soluble Meta-Tungstate. *APSP*. 1926.
Observations on Soluble Meta-Tungstates. *CN*. 1927.

BROCHURES ON AMERICAN CHEMICAL HISTORY

THEODORE G. WORMLEY, JR. *JACS*. 1897.
ROBERT EMPIE ROGERS. *NASM*. 1905.
GEORGE F. BARKER. *AJS*. 1907.
FAIRMAN ROGERS. *NASM*. 1909.
DAVID RITTENHOUSE. 1914.
Men of Science from the Keystone State. 1914.
BENJAMIN SMITH BARTON. 1916.
The American Spirt in Chemistry. *JIEC*. 1919.

Progress of Chemistry. Address American Chemical Society. 1921.
Our Science. Address American Chemical Society. 1922.
JAMES CURTIS BOOTH. 1922.
FRANKLIN BACHE. 1922.
SAMUEL LATHAM MITCHELL (Chandler Lecture, Columbia University). 1922.
PRIESTLEYANA. 1922.
M. CAREY LEA. 1923.
JACOB GREEN. 1923.
MARTIN HANS BOYÈ. 1924.
JOHN GRISCOM. 1925.
A Half Century of Mineral Chemistry in America, 1876-1926. *JACS*. 1926.
Observations on Teaching the History of Chemistry. *JCE*. 1926.
Fragments Relating to the History of Chemistry in America. *JCE*. 1926.
Forgotten Chemists. *JCE*. 1926.
Bromine and Its Discoverers. *JCE*. 1926.
Early Science in Philadelphia. *PM*. 1926.
JOSEPH PRIESTLEY (Priestley Medal Lecture). *S*. 1926.
JAMES BLYTHE ROGERS. 1927.
A Look Backward. *JCE*. 1927.
ROBERT HARE. *ASS*. 1927.

VOLUMES ON AMERICAN CHEMICAL HISTORY

Chemistry in America. New York. 1914.
ROBERT HARE—An American Chemist. Philadelphia. 1917.
JAMES WOODHOUSE. Philadelphia. 1918.
Chemistry in Old Philadelphia. Philadelphia. 1918.
JAMES CUTBUSH. Philadelphia. 1919.
Priestley in America. Philadelphia. 1920.
Old Chemistries. New York. 1927.

ORIGINAL AND TRANSLATED CHEMICAL TEXTS

CLASSEN'S Quantitative Analysis. (Translation.) Philadelphia. 1878.
Chemical Analysis of the Urine. With John Marshall, M.D. Philadelphia. 1881.
VON RICHTER'S Inorganic Chemistry. (Translation.) Philadelphia. 6 editions (1883-1900).
VON RICHTER'S Organic Chemistry. (Translation.) Philadelphia. 4 editions (1883-1900).
Chemical Experiments. With Dr. H. F. Keller. Philadelphia. 10 editions (1890-1900).
Electrochemical Analysis. Philadelphia. 6 editions (1890-1918). German editions, 1893 and 1908; French editions, 1900.
OETTEL'S Introduction to Electrochemistry. (Translation.) Philadelphia. 1893.

OETTEL's Practical Exercises in Electrochemistry. (Translation.) Philadelphia. 1897.

Elements of Chemistry in Lecture Form. Philadelphia. 7 editions (1908-18).

Elements of Electrochemistry. Philadelphia. 1913 and 1917.

Theories of Chemistry. Philadelphia. 1913.

Chemical Experiments, Shorter Course. Philadelphia. 1913 and 1923.

Atomic Weights. Philadelphia. 1915.

DOCTORATE THESES IN CHEMISTRY

(Theses carried out under direction of Edgar Fahs Smith)

H. WILEY THOMAS, Muhlenberg College. The Electrolysis of Bismuth Solutions (1883).

H. S. WARWICK: Electrolysis of Metallic Formates (1891).

LEE K. FRANKEL: Oxidation of Metallic Arsenides by the Electric Current (1891).

S. C. SCHMUCKER: Electrolysis of the Metals of the Second Group (1893).

A. P. BROWN: Constitution of Pyrite and Marcasite (1894).

THOMAS LIGHTFOOT: Constitution of Arsenopyrite (1894).

R. H. BRADBURY: Reaction between Molybdic Acid and Potassium Bichromate. (1894).

C. H. EHRENFELD: A Study of the Behavior of Tungsten and Molybdenum and their Trioxides (1894).

FANNY R. M. HITCHCOCK: Tungstates and Molybdates of the Rare Earths (1894).

MARY E. PENNINGTON: Derivatives of Columbium and Tantalum (1895).

A. N. SEAL: The Action of Acid Amides on Benzoin (1895).

W. L. HARDIN: Determination of the Atomic Masses of Silver, Mercury and Cadmium by the Electrolytic Method (1896).

J. BIRD MOYER: Metal Separations by Means of Hydrochloric Acid Gas (1896).

O. L. SHINN: The Atomic Mass of Tungsten (1896).

J. G. HIBBS: Action of Hydrochloric Acid Gas upon Arsenates and Nitrates (1896).

ENRI D. DESI: University of Geneva 1896. Thesis carried out at the University of Pennsylvania under the direction of E. F. S. and so acknowledged in its printing.

L. A. RYAN: Derivatives of Pyroracemic Acid (1897).

J. F. X. HAROLD: Derivatives of Silicon Tetrachloride (1897).

H. B. HARRIS: The Volumetric Determination of Cobalt (1897).

V. LENHER: The Atomic Mass and Derivatives of Selenium (1898).

J. M. MATTHEWS: Derivatives of the Tetrahalides of Zirconium (1898).

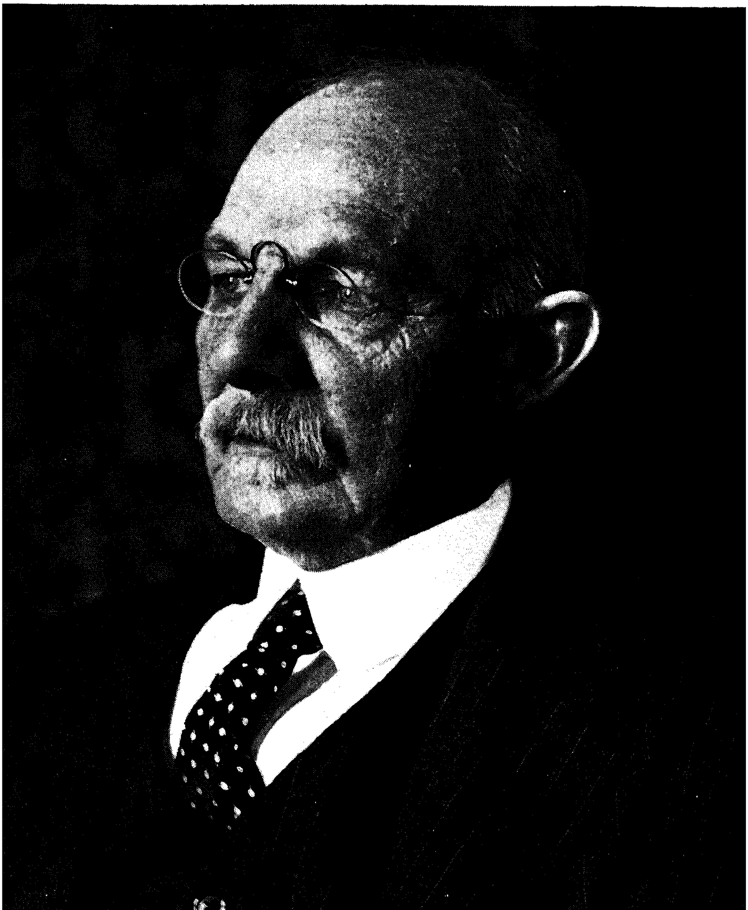
W. M. GROSVENOR: A Study in Electrolytic Reduction (1898).

G. E. THOMAS: The Atomic Mass of Tungsten (1898).

G. W. SARGENT: Quantitative Determination of Boric Acid in Tourmaline (1898).

ELIZABETH A. ATKINSON: Metal Separations by Means of Hydrobromic Acid (1898).
J. H. JAMES: An Electrolytic Study of Benzoin and Benzil (1899).
A. TINGLE: The Influence of Substituents on the Electric Conductivity of Benzoic Acid (1899).
LILY G. KOLLOCK: Electrolytic Determinations and Separations (1899).
C. L. SARGENT: The Production of Alloys of Tungsten and of Molybdenum in the Electric Furnace (1900).
G. W. ROCKWELL: An Electrolyptic study of Pyroracemic Acid (1900).
W. C. EBAUGH: The Atomic Weight of Arsenic (1901).
T. M. TAYLOR: Atomic Weight of Tungsten and the Ammonium Tungstates (1901).
ALICE McM. JEFFERSON: Aromatic Bases as Precipitants for Rare Earth Metals (1901).
G. H. BOGGS: Action of Hydrochloric Acid on Vanadates (1901).
L. P. WYMAN: The Purification of Tungstic Acid (1902).
ALLEN ROGERS: Derivatives of New Complex Inorganic Acids (1902).
A. T. KAMMERER: The Electrolytic Estimation of Bismuth, etc. (1902).
W. H. EASTON: The Reduction of Nitric Acid in Metallic Nitrates by the Electric Current (1903).
B. L. HARTWELL: The Precipitation of Cerium, etc., by Certain Organic Bases (1903).
G. P. SCHOLL: The Electrolytic Precipitation of Manganese (1903).
W. T. TAGGART: The Electrolytic Precipitation of Nickel from Phosphate Solutions (1903).
F. F. EXNER: The Rapid Precipitation of Metals in the Electrolytic Way (1903).
L. D. HALL: Observations on the Metallic Acids (1904).
L. H. INGHAM: The Use of the Rotating Anode in the Electrolytic Estimation of Zinc and of Nitric Acid (1904).
H. W. BRUBAKER: Derivatives of Complex Inorganic Acids (1904).
SARAH P. MILLER: Determination and Separation of Gold in the Electrolytic Way (1904).
D. S. ASHBROOK: Electrolytic Separations Possible with a Rotating Anode (1904).
R. E. MYERS: Results obtained in Electrochemical Analysis by the Use of a Mercury Cathode (1904).
M. H. BEDFORD: Columbates (1905).
J. R. WITHROW: The Electrolytic Precipitation of Gold, etc. (1905).
R. O. SMITH: The Rapid Precipitation of Lead and Mercury in the Electrolytic Way (1905).
ALICE L. DAVISON: The Electrolytic Determination of Cadmium, with the Use of a Rotating Anode (1905).
C. W. BALKE: Double Fluorides of Tantalum (1906).
JULIA LANGNESS: Electrolytic Determinations and Separations with the Use of a Rotating Anode (1906).

J. H. HILDEBRAND: Determination of Anions in the Electrolytic Way (1906).
ANNA L. FLANIGAN: The Electrolytic Precipitation of Copper from an Alkaline Cyanide Electrolyte (1906).
L. F. WITMER: The Electrolytic Determination of Tin (1906).
T. P. MCCUTCHEON: New Results in Electroanalysis (1907).
JOHN FRAZER: The Application of the Rotating Anode to Certain Electrolytic Separations (1907).
G. W. MORDEN: The Determination of Thallium in the Electrolytic Way (1908).
HARRISON HALE: An Electrolytic Method of Analyzing Zinc Ores (1908).
W. M. BARR: A Study of the Spectrum and Bromides of Columbium (1908).
L. C. DANIELS: Derivatives of Complex Inorganic Acids (1908).
GEORGE I. KEMMERER: The Atomic Weight of Palladium (1908).
W. BLUM: Experiments on the Atomic Weight of Cadmium (1908).
MARY E. HOLMES: The Use of the Rotating Anode in Electrolytic Separations (1908).
J. A. SCHAEFFER: Double Fluorides of Titanium (1908).
C. McD. GILLAN: The Composition of Ammonium Phospho-Molybdate (1909).
W. K. VAN HAAGEN: Tantalum and Some of its Halides (1909).
W. H. CHAPIN: Halide Bases of Tantalum (1909).
J. L. K. SNYDER: Double Fluorides of Titanium and Zirconium (1909).
B. L. GLASCOCK: Metallic Strontium (1909).
G. W. PLUMMER: The Constitution of Marcasite and Pyrite (1910).
J. H. MÜLLER: The Action of Salicylic Acid upon the Metallic Acids (1910).
G. V. BROWN: The Determination of Manganese by Various Gravimetric Methods (1910).
D. J. MCADAMS: The Atomic Weight of Vanadium (1910).
J. S. GOLDBAUM: The Atomic Weights of Chlorine and Bromine (1910).
W. B. HICKS: The Use of Sulphur Monochloride in the Decomposition and Analysis of Rare Earth Minerals (1911).
N. K. CHANEY: The Electrolytic Precipitation of Antimony (1912).
H. S. HARNED: Halide Bases of Columbium (1913).
H. S. LUKENS: Scandium in American Wolframite (1913).
E. E. Marbaker: Separation of Molybdenum and Tungsten (1914).
T. R. ALEXANDER: The Quantitative Determination of Chromium (1915).
WILLIAM ADOLPH: The Determination of Fluorine (1915).
J. B. HILL: Some New Derivatives of Tungsten (1916).
O. R. SWEENEY: A Separation of Arsenic, Antimony and Vanadium from Tungsten: On the Complex Bismuthico Tungstates (1916).
HARRY BECKERMAN: I. Tungsten Hexabromide. II. Tungsten Complexes (1918).



W S Halsted

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVII—SEVENTH MEMOIR

BIOGRAPHICAL MEMOIR

OF

WILLIAM STEWART HALSTED

1852–1922

BY

W. G. MacCALLUM

PRESENTED TO THE ACADEMY AT THE AUTUMN MEETING, 1935

WILLIAM STEWART HALSTED

1852–1922

BY W. G. MAC CALLUM

William Stewart Halsted was born in New York on September 23rd, 1852. He came from a family of Halsteds in England who, in the 16th century, had an estate in Rowley Parish called High Halsted. They were closely connected by intermarriage with the Townley family and it was as son of William Miller Halsted and May Louisa Haines (daughter of Richard Townley Haines) that he was born. His family in New York was prominent financially and active in various philanthropic projects. He himself as a boy was sent to a private school at Monson, Mass., later to Andover in 1863, and graduated from there to go to Yale, which college he entered in 1870, graduating in 1874. At Yale he spent most of his time in athletics, especially in rowing, baseball and gymnastics. In his senior year he was captain of the football organization and made the winning goal in the celebrated game with Eton which Yale won 2 to 1.

After graduating from Yale he entered the College of Physicians and Surgeons in New York, with Dr. Henry B. Sands as preceptor. Later in his course he became assistant to Prof. John C. Dalton, the physiologist whose interest was especially in cerebral localization, but most of his time was spent in dissection. He had some association with Alonzo Clark, in whose office he made some chemical tests. Then, in 1876, before graduating in medicine, he was admitted as interne in the Fourth Surgical Division at Bellevue, where he followed the medical work of Janeway, Loomis and Jacobi, but was especially associated with the surgeon Hamilton, in whose service he invented various methods of treating fractures, and the use of continuous hot baths in infections. In 1877 he graduated with honors from the College of Physicians and Surgeons and was appointed House Physician at the New York Hospital where he saw much of Draper, Seguin, Hackley and Woolsey Johnson. There he

devised a new form for hospital temperature charts which is still in general use.

In 1878 he went for the first time to Europe and in Vienna attended courses with Chiari, Fuchs, Pollitzer, Kaposi and especially with Zuckerkandl in anatomy. He attended the clinics of Billroth and met Woelfler and Mikulicz of whom he saw much. Then, in 1879, he went to Würzburg to take a course in embryology with Kölliker, and histology with Stoehr and visited the clinics of von Bergmann. In 1880, he spent some time in Leipzig where he knew Weigert and attended the clinics of Thiersch and Wagner. Then to Halle, where he spent several profitable weeks with Volkmann, and after that to Schede in Hamburg and Esmarch in Kiel, returning to New York early in September, 1880. These two years, from the autumn of 1878 to that of 1880, were fortunate in that he watched the great progress in many branches of medicine and perhaps especially the development of Lister's antiseptic surgery by the German surgeons, and, also, in that he came in contact with the most able men of that day who were pioneers in their fields.

On his return he became the associate of Sands at the Roosevelt Hospital where he not only operated in the surgical clinic but inaugurated an outpatient department and, with Hall, Hartley and Markoe, studied especially the antiseptic treatment of gonococcal infections. Beside this he, with Munroe and later Tuttle and West Roosevelt, carried on a quiz for several years. This was very successful because of its practical character and many of the men now well known were students in the wards and at the recitations held in his house on Twenty-fifth Street, and were received by Dr. Welch in his demonstrations in pathology at Bellevue. At the same time he was demonstrator in anatomy under Sands in the College of Physicians and Surgeons, and there much associated with Thomas A. Sabine. He was visiting physician at the Charity Hospital on Blackwell's Island and next year Surgeon-in-Chief at the Emigrant Hospital on Ward's Island. How he ever managed to carry on so many and varied activities it is hard to understand. In 1883 he was appointed visiting physician to Bellevue. In the same year he was put on the visiting staff of the

Presbyterian Hospital and in the summer had the surgical service at the Chambers Street Hospital, when William T. Bull was away. There he devised a method of transfusion of blood in patients poisoned with illuminating gas.

Through these years from 1880 to 1885 he worked with superhuman energy and endurance, caring for the outpatient department of Roosevelt in the mornings, with five other hospitals demanding his services in wards and operating rooms at any time, with regular hours of teaching in the dissecting rooms at the College, and with his quiz of sixty-five or more students at his house. Despite this great burden, it was then that his best ideas were evolved and the germ of most of his later work began to appear. He, with Hall, did much to establish in New York the principles of antiseptic surgery and invented new dressings for wounds. He was impressed by the discovery of Koller that the cornea could be anaesthetised with cocaine, a method which was first made public at the Heidelberg Ophthalmic Congress in 1884, and they began experimenting with this substance. It was then he found that he could by injecting it into a sensory nerve, block all conduction through that nerve and so render the whole area from which its branches came, insensitive to pain. This was a most important discovery and has been utilized ever since. But, in thus experimenting upon themselves and students, they did not realize that cocaine is a demoralizing habit-forming drug and neither Dr. Halsted nor his co-worker, Hall, escaped, but through superhuman strength and determination Halsted at last overcame it. After an interval of more than a year he came back to a more thoughtful leisurely life with time for reflection and contemplation of his surgical problems, a life in the end far more fruitful than could ever have been the strenuous rush of his existence in New York, if he had kept on at that pace. After all, in his case it was probably no misfortune but rather the reverse.

It was in 1886 that at Dr. Welch's invitation he came to Baltimore and for a time they lived together. During the winter of 1886-87 he began work in Dr. Welch's laboratory supported and encouraged by him. There he found Councilman, Nuttall, Abbott, Herter and others, among whom Mall

especially impressed him. He and Dr. Halsted became close friends and worked together on experiments on the end-to-end suture of the intestine in which they recognized the importance of the submucosa in holding the suture. Later, Dr. Halsted turned his attention to the study of compensatory hypertrophy in the thyroid after partial removal. Both of these studies gave results of permanent value. From the beginning of his work in the laboratory, however, there remained his earlier interest in the treatment of wounds. He realized that Lister's work was throughout concerned with the prevention of the access of bacteria to the wound by methods which were of good intention but in general fallacious while ignoring the great importance of the delicate handling of tissues and their accurate adjustment for healing. It became clear to him that bacteria might survive the use of antiseptics and that it is especially important that no dead tissue which might form a medium for their growth should be left in the wound and that no vacant space should be left in which fluid might accumulate with the same result. Blood clots he recognized as slightly defensive, so that they were sometimes intentionally allowed to fill a space.

Such study engaged his attention throughout all his later years, even when his technique had, with the advent of the more strictly aseptic methods, become extraordinarily precise. But it was always the treatment of the tissues which seemed to him most important. If they were exactly brought together as nearly as possible in their normal relations with no dead space, perfect haemostasis and with good circulation in all the tissues, none of which had been roughly handled so as to cause the death of cells, then healing might progress uninterruptedly—even if a few bacteria were left. He had found that in the intact peritoneum of a dog bacteria were soon destroyed, whereas if any dead tissue were left there, perhaps by tying a ligature about a considerable mass of blood vessels and other tissue to stop bleeding, generalized infection would result. But he was equally careful about the introduction of any bacteria and invented the subcutaneous suture to avoid passing through the skin which could not be completely disinfected. Instead of

catgut he used silver wire which helped in the defense, the surgeon's hands and the patient's skin were disinfected with permanganate and then with bichloride of mercury and he introduced sterilized rubber gloves for the operator's hands. Some of this was of course of gradual development after the opening of the Johns Hopkins Hospital, in 1889, but most of it had been worked out experimentally on dogs during his years in the laboratory.

The hospital was formally opened in May of 1889 and Dr. Osler was appointed Professor of Medicine, Dr. Halsted Associate Professor of Surgery, Dr. Kelly Associate Professor of Gynaecology and Obstetrics. Dr. Welch had been made Professor of Pathology in 1884, with Dr. Councilman as Associate. Dr. Halsted was head of the Out-patient Department and Acting Surgeon to the Hospital. Shortly after this he was made Surgeon-in-Chief and in 1892, Professor of Surgery. Miss Caroline Hampton was head nurse for the Surgical Service and later Dr. Halsted had her appointed head nurse in the operating room. It was because of her suffering from the inflammation of her hands and arms, produced by the antiseptics, that he first devised the rubber gloves. She was a Southerner from North Carolina, and one of a distinguished family there, the daughter of Frank Hampton, who had married Sally Baxter in 1855, and niece of Wade Hampton. Their stately house at Millwood, near Columbia, had been destroyed by Sherman's soldiers and after the death of her parents, she and her sister were cared for by their aunts. She had gone to New York, in 1886, and graduated as a trained nurse at the New York Hospital in 1888.

Dr. Halsted and Miss Hampton were married in June 1890 at Millwood and went to the family hunting lodge at Cashiers in the mountains for their wedding trip. Later he bought this place from the aunts and called it High Hampton. Every summer they spent much time there and it became the real centre of Mrs. Halsted's life, rather than the house at 1201 Eutaw Place in Baltimore, because that country appealed to her so much more than the city.

From this time on Dr. Halsted's work in the hospital aimed

at three things—to perfect the technical methods of surgery, to study experimentally and otherwise the several topics which from the beginning had engaged his interest, and above all, to establish a school of surgery by training his assistants so thoroughly and through so long a time that they might leave him and transmit his teaching, undiminished, in other schools. In these three aims he was successful, as may be learned from a study of surgery as it exists in a great many hospitals throughout this country and even from observations of the results of his influence abroad.

With the beginning of his surgical service in the new hospital, his attention was more or less concentrated on his efforts to treat cancer of the breast, on the radical cure of hernia, and upon the healing of wounds, especially under a moist blood clot. The details of these studies cannot be repeated here but it may be reiterated that in all, the fundamental principles concerned in the protection of tissues from unnecessary injury and their readaptation to a nearly normal position with maintenance of an adequate blood supply, seemed to him of primary importance in securing healing and avoiding infection.

He was always experimenting with methods and materials and devised needles, glass spools, mosquito clamps, etc., that are now used everywhere. The equipment of his operating room was very simple and there was none of the marble and shining nickle that seems necessary in the modern operating room. There was only a wooden table which he invented and the glass vats of powerful antiseptics for hands and arms. But everything was sterilized and the technique of the antiseptic approach to asepsis was rigorous and even painful to the staff.

In 1893 the Johns Hopkins Medical School was opened with a small class and when these students came to him for the course in surgery they found his teaching not at all such as it was when he was a quiz-master in New York, but rather that of an investigator who discussed at length the subjects that especially interested him. In the operative clinics they found most impressive not his dexterity or brilliance in operating, but his intense interest in the pathological condition and in his concentration on a plan of operation which would most surely

relieve the situation and lead to the ultimate healing of the patient. His teaching was through example and not through dogmatic statement. It was first-hand knowledge that they gained from an eager inquirer who allowed them to see what had stirred his interests, what difficulties he had encountered and his best efforts to overcome them.

His summers he spent in long vacations at High Hampton although he made many trips to Europe. In Baltimore he saw much of a small group of friends at the Maryland Club where they gathered in the old club building on Franklin Street. They were Dr. Welch, Major Venable, Dr. Frank Donaldson, Dr. Lockwood and some others. But after his marriage, when the club moved to its new building on Eager Street, he was hardly ever there except when Mrs. Halsted had gone south to High Hampton. He never played cards or any of the other games that pass time in a club, but he had always been interested in boxing and often went to boxing matches or prize fights in a theatre far down in the town. At High Hampton he followed Mrs. Halsted's interests in the planting and harvesting of various crops, in her expert handling of horses, whether in driving or riding, and strove to fit himself to accompany her on her cross country gallops. They always had several dogs which interested him, and in an amateurish way he studied the stars through a large telescope which he had set up at their southern home. He delighted particularly in their garden where he concentrated his attention on dahlias, ordering the bulbs from foreign dealers. His success in growing these attracted dahlia lovers to High Hampton to see his wonderful display.

"The Professor," as he was always called, was a severe judge of young men and extremely exacting in his estimate of the abilities of those whom he was willing to retain as his assistants. His accuracy in such recognition of talent and worth is attested by the list of those whom he trained to a career in surgery. Unlike some surgeons who prefer to operate alone, he wanted all the assistants who could to take part in an operation but they must be silent and unobtrusive. He foresaw their capabilities and practically decided for them the future

character of their work, some to be general surgeons, others to concentrate upon some special field such as otology and laryngology or the surgery of the nervous system. Still others he chose to be his associates in carrying out his own experimental studies. Even a partial list of the men of his staff in former years will give an idea of the results, for they were Finney, Cushing, Bloodgood, Mitchell, Young, Crowe, Follis, Heuer, Dandy, Reid, Rienhoff, and many others. He always gave the most serious thought to the future of his assistants and counselled them as may be seen in the following extracts from a letter to one of them. "The next ten years of your life should naturally be the most fertile ones and there is probably nothing from which in later years you will derive so much satisfaction as from the contributions of yourself and your assistants to science. In the building up of a school you will have to sacrifice yourself to the interests of the school and of your assistants. The head of a department in a school should give his problems freely to his assistants, rather than to technicians and salaried students, the results of whose work would redound to his own glory."

During these years he was concerned with the operative treatment of gallstones and in 1896 described a device for the accurate suture of the common duct. Later papers dealt with acute pancreatitis caused by obstruction and backflow of bile into the pancreatic duct and with the effects of continued loss of bile through drainage. In 1903 he began once more to work on the surgery of the thyroid gland and especially upon the treatment of exophthalmic goitre which involved also the problem of tetany from accidental removal of the parathyroids. The nature of tetany having been cleared up about this time he studied especially the position and blood supply of the parathyroids and planned his operation for excision of a large part of the thyroid in such a way as to leave them uninjured. All of this is described in detail in his "Operative Story of Goitre." Later, he experimented with the transplantation of parathyroid glands which he seemed to find successful only when there was already a deficiency or need for this tissue. In a paper published in 1914 he reviews 650 cases of exophthalmic goitre upon which

already he had operated with good results, and this figure must have been greatly increased before his death. In his Harvey Lecture he spoke especially of the relation of the thymus to this disease, a question which still remains obscure.

With foreign surgeons his relations were friendly, almost intimate, and he made it his duty and pleasure to visit their clinics to watch and discuss their work. He was always an adherent of the German attitude toward surgery in principle although often critical of particular features. He admired Theodore Kocher especially but also maintained a correspondence with v. Mikulicz, v. Eiselsberg, Küttner, and others, and sent his assistants to work with such men. Leriche, of Strasbourg, visited him here and later wrote a most appreciative description of his methods and of his work, especially impressed as he was with the experimental attitude and with the course in experimental surgery which Dr. Halsted originated and then gave over to Cushing. He said, "In Baltimore the fusion of surgery and physiology is intimate and future surgeons are trained in a laboratory of experimental surgery in contact with living beings and not in a dissecting room." He goes on to describe the principal points in such surgical operations as he witnessed, the use of rubber gloves, the avoidance of catgut, the horror of mass ligatures, the anatomical reconstruction of the separated tissues, the suppression of drainage and the careful dressing with silver foil. "Halsted is the most exquisitely unaffected man one could find. It is because he is so simple and direct that he has been able to group around him and retain at his side assistants of whom most have for a long time been masters. It illustrates admirably the truth of the phrase 'the worth of a professor is measured by the personality of those whom he has trained.' "

Dr. Halsted visited Payr of Leipzig and Enderlen in Würzburg and Martel and Quenu in Paris. Later, in 1911 and in 1914, he attended the Congresses of the German Surgical Association of which he was made an honorary member, and spent much time in Berne visiting Kocher with whom he kept up the warmest friendship.

As long ago as 1892, he entered upon what he afterward

spoke of as a "vibrant domain of surgery," the operative removal of an aneurysm which involved the ligation of large arteries. This led him to a prolonged study of the immediate and more remote results of the closure of such a large artery as the subclavian or femoral, a study which with Reid, Holman, Reichert and others lasted for the rest of his life. He devised a metal band for the partial or complete occlusion of the artery and realized the danger of haemorrhage when the arterial wall was greatly diseased and of the necessity of allowing time by partial occlusion for the development of a collateral circulation—all details in a very complex problem whose complete solution seems questionable. His study of the "Ligation of the Left Subclavian Artery in its First Portion," seems to be the best of all his papers. It is largely a review of the history of the subject including that of arteriovenous aneurysms which throws much light on the physiological principles involved. Further work on the obstruction of the lymphatics, veins and arteries was carried on by his assistants in an effort to explain the swelling of the arm so often observed after an extensive operation for the removal of a cancer of the breast. It proved that such swelling cannot be due to mechanical obstruction alone but is the result of infection.

In August, 1919, Dr. Halsted returned from his house in the south with symptoms of gall-stone colic and underwent an operation by Dr. Follis who removed the gall-bladder. He recovered and carried on his work through 1920 and 1921, devising a new method of intestinal suture. He remained fairly well through the spring of 1922, and in April a great banquet was organized in his honor by the Maryland State Dental Association for the presentation of a gold medal by the National Dental Association in recognition of his discovery of local anaesthesia. This gave him great happiness, as he wrote to his friend, Dr. Matas, of New Orleans. In June, 1922, as he was walking near the Pathological Laboratory he was induced to come in and be photographed, despite his disinclination which was well known, and this is therefore the date of the accompanying portrait. In August of 1922 he returned hurriedly from the south and underwent another operation by Heuer and

Reid. But in spite of their watchful care, he sank and died on September 7th, 1922. It was found that the operation had been perfectly successful but that he had developed pneumonia and pleurisy.

It is difficult, if not impossible, to give an adequate impression of the man whose personality was so hidden in his habitual reserve and so hedged round with the formality of his manner toward those who did not know him well, although to a few he was on terms of complete intimacy and vivacious companionship. He was very shortsighted, not very tall, and his powerful shoulders were a little stooped. He walked with deliberate measured tread and his arms were held bowed out a little, which gave the impression of great muscular strength. He looked neither to right nor left and seemed surprised if someone spoke to him, and in any conversation which followed his formality and extreme politeness hampered the other person a good deal and the interview finally ended in the same key. But with Dr. Welch, or others of his intimate circle, he was all bright attention, eager to miss nothing of what might be said. Their talks in the little chess-room of the Maryland Club with Major Venable and Mr. Frank Hambleton were full of amusing and brilliant repartee in which no one equalled Dr. Halsted. His interests and consequently his reading were not widespread and he had nothing of Dr. Welch's omnivorous appetite for books on every topic. He was not interested in poetry or general literature, nor did he care for painting or sculpture, but he was really expert in the matter of antique furniture and old rugs and his home was full of wonderful examples. He seemed to know or care little for music but did enjoy the theatre. In business matters he was very naïve and had little or no ability to deal with such things as investments. His courage and self possession in the emergencies that arise in the course of operations or in any other situation were remarkable and he was never disturbed or unduly excited in any contretemps. His experimental studies were concerned with the several fundamental problems which in their manifold details always interested him and he had notebooks in which he had put down innumerable suggestions for future work. But

in general he persisted with experiments quite closely related to his major problems and this tenacity of purpose brought him his best results. He treasured the leisure from routine operating which was given him by the full-time system for his experimental studies, and drew some of his assistants into this work in such a way that he was later to be proud of their development and confirmed in his attitude of intense devotion to the training of his chosen staff.

In attempting to estimate the significance of Dr. Halsted's work it seems that his greatest service was not so much his surgical discoveries and inventions, many and important as these were, as his attitude in operating upon the human body which must forever be the proper attitude of the surgeon. It was simply the recognition of the normal or physiological condition of the tissues which one should attempt to restore, realizing their natural defense and the reasons for their vulnerability. It was not concentrated upon invading bacteria as were the antiseptic method of Lister and the aseptic method of von Bergmann and Schimmelbusch but rather on the maintenance of the normal defenses of the tissues although incidentally, of course, his operative technique was clean.

Dr. Halsted was never inclined to public appearance and shunned publicity. He was the recipient of some honorary degrees and corresponding memberships in foreign societies but they were comparatively few—a list of these is given below.

He was not inflated with self-esteem, he did not advertise and he was not a politician, the things which lead to present but not to permanent fame. But he made lasting contributions to the world's knowledge and his name will endure.

His most important single contributions may be briefly listed as follows:

1880—Gutta percha films for dressings and drainage.
1884—Cocaine in block anaesthesia by injection into nerves.
Centripetal transfusions of blood in illuminating-gas poisoning.
1886—Treatment of gonococcal urethritis by flushing with weak bichloride of mercury.
1887—Recognized importance of submucosa in intestinal sutures.
1888—Described compensatory hyperplasia in thyroid.
1889—Devised radical operation for cure of cancer of the breast.

1890—Introduced use of rubber gloves in operations.
Devised operation for the cure of inguinal hernia.
1891—Ligated subclavian artery with the first excision of a subclavian aneurysm.
1893—Performed first choledochotomies in America.
1896—Introduced silver foil as dressing for closed wounds.
1905—Transplanted successfuly parathyroid glands in dogs.
1912-1922—Improved operations on aneurysms and mammary cancer and devised new methods of draining the common bile duct, and performing intestinal anastomosis. Proved infectious origin of swelling of the arm after operation for cancer of the breast, and demonstrated with Reichert and Reid that whole limbs may be successfully transplanted without anastomosis of blood vessels.
Author of monographs on goitre and the surgery of the great arteries.

TITLES AND HONORS

Honorary Fellow of the Royal College of Surgeons, England, 1900; Edinburgh, 1905.
Honorary L.L.D., Yale 1904; Edinburgh 1905.
Honorary Sc. D., Columbia 1904.
Foreign Corresponding Member, Harveian Society (Hon.).
Membre Corresp. Etranger de la Société de Chirurgie, Paris, 1909.
Honorary Fellow, American College of Surgeons, 1913.
Ehrenmitglied d. Deutsche. Gesellschaft für Chirurgie, 1914.
Membre titulaire de l'Assoc. française de Chirurgie, 1914.
Honorary Member, American Society for Experimental Pathology, 1916.
Foreign Member, Kungl. Svenska Vetenskaps Akademien, Stockholm, 1917.
Honorary Member, Societas Medicorum Sverana, Stockholm, 1918.
Membre honoraire etranger, Académie Royale de Médecine de Belgique, 1920.

MEMBERSHIPS

Member, National Academy of Sciences, 1917.
Associate Fellow, American Academy of Arts and Sciences.
Fellow, American Surgical Association.
Fellow, American Association for the Advancement of Science.
Member, Society for Experimental Biology and Medicine.
Member, American Association of Pathologists and Bacteriologists.
Member, American Association of Anatomists.
Member, American Medical Association.
Awarded Gold Medal of American Dental Association, 1922.

BIBLIOGRAPHY

Case of intestinal incarceration. N. Y. Med. Jour., 1883, XXXVII, 241.
Sliding apparatus for extension in fracture of femur. Med. News, 1883, XLII, 284.

Refusion in treatment of carbonic oxide poisoning. N. Y. Med. Jour., 1883, XXXVIII, 625.

Lower limit of the pleural cavity. N. Y. Med. Jour., 1883, XXXVII, 100.

Excision of one centimetre of the inferior dental nerve. N. Y. Med. Jour., 1883, XXXVII, 386.

Ligation of the lingual artery. N. Y. Med. Jour., 1883, XXXVII, 637.

Removal of foreign bodies. N. Y. Med. Jour., 1883, XXXIX, 226.

Adduction and abduction in fractures of the neck of the femur. ibid, 1884, XXXIX, 251.

Effects of adduction and abduction on the length of limb in fractures of the neck of the femur. ibid, 317.

Cases of partial resection of elbow and shoulder for tuberculosis and of the ankle for traumatism. ibid, 1884, XL, 619.

Relation of the infraorbital canal to reproduction of the superior maxilla. ibid, 1884, XXXIX, 48.

Hemiplegia following stab wound between occiput and atlas. ibid, 1884, XXXIX, 103.

Passage of emboli through the lungs. ibid., 1884, XXXIX, 312.

Aseptic surgery in New York in 1884. ibid, 1884, XL, 497.

Freedom from haemorrhage of intercostal arteries in thoracotomy. ibid, 1884, XL, 498.

Determination of length of limb in fracture of neck of femur. ibid, 621.

Abdominal interference to lumbar incision for removal of kidney neoplasm. ibid, 734.

A new needle holder. ibid, 1885, XLI, 79.

Practical comments on the use and abuse of cocaine in minor surgical operations. ibid, 1885, XLII, 294.

Water as local anaesthetic. ibid, 327.

Descent of femoral hernia. ibid, 1885, XLI, 368.

Circular suture of the intestine—an experimental study. Am. Jour. Med. Sc., 1887, XCIV, 436.

Treatment of cancer of the breast—discussion. Maryland Med. Jour., 1888, XIX, 29.

Radical cure of hernia. Bull. Johns Hopkins Hosp., 1890, I, 12.

Two cases of reflex nerve manifestations cured by operation. ibid, 35.

Healing of wounds under the moist blood scab. ibid, 46.

Epispadias: intestinal obstruction: appendicitis. ibid, 59—title only.

Amputation of breast, etc. ibid, 59—title only.

Un-united fracture of hip, etc. ibid, 62—title only.

Cicatricial jaw ankylosis. ibid, 111.

Crush of elbow. Organization of blood clot. ibid, 112.

Skin grafting. ibid, 112.

Radical cure of hernia. ibid, 112, also, 1891, II, 63.

Tumor of undescended testicle. ibid, 113. Title only.

Intestinal anastomosis. ibid, 1891, II, 1.

Treatment of wounds with especial reference to the value of blood clot in the management of dead spaces. Johns Hopkins Hosp. Report 1890-91, II, 255.

Spurious ankylosis of the jaws. Bull. Johns Hopkins Hosp., 1891, II, 62.

Iodoform oil injections for tuberculosis of hip. ibid, 104.

Osteoplastic operations for obliteration of involucral cavity. ibid, 160.

Plastic operation for obliteration of cavity in lower end of femur. ibid, 160.

Suppurating compound comminuted fracture into ankle joint. ibid, 160.

Needle-holder for Hagedorn's needles. ibid, 63.

Colles' fracture. ibid, 1892, III, 30.

Excision of veins of the cord in radical cure of inguinal hernia. ibid, 76.

Ligation of the first portion of the left subclavian artery and excision of a subclavio-axillary aneurysm. ibid, 93.

Report in Surgery. Johns Hopkins Hosp. Reports, March, 1891.

Review of Schimmelbusch. Anleitung zur Aseptischen Wundbehandlung. Bull. Johns Hopkins Hosp., 1892, III, 63.

Radical cure of inguinal hernia in the male. ibid, 1893, IV, 17.

Laparotomy for intussusception. ibid, 43.

Tuberculous knee joint. ibid, 97.

Goitre. ibid, 97.

Operative treatment of old dislocations of elbow. ibid, 97.

Recurrent volvulus. ibid, 28.

Bactericidal properties of the blood. The effect of strangulation of the tissue upon local infection. Maryland Med. Jour., 1893, XXVIII, 404.

Gastro-enterostomy and adhesions. Bull. Johns Hopkins Hosp., 1893, IV, 54.

Excision of knee joint in which Hansmann's plates were employed. ibid, 1894, V, 31.

Diagnostic sign in appendicitis. ibid, 32, 113.

Operative treatment of cancer of the breast. Maryland Med. Jour., 1894, XXXI, 109.

Radical cure of hernia. Bull. Johns Hopkins Hosp., 1894, V, 98.

Results of operations for cure of cancer of the breast. Johns Hopkins Hosp. Reports, 1894-5, IV, 297.

Congestion of head and neck and protrusion of eyeballs upon abdominal pressure. Bull. Johns Hopkins Hosp., 1894, V, 33.

Operative treatment of hernia. Am. Jour. Med. Sc., 1895, CX, 13.

Glottis kept open by forward pressure on angle of jaw in anaethesia. Bull. Johns Hopkins Hosp., 1895, VI, 4.

Concerning inflammation and suppuration. Trans. Am. Surg. Assoc., 1895, XIII, 249.

Concerning operative treatment of hernia. ibid, 343.

Irrigations with bichloride solutions. Bull. Johns Hopkins Hosp., 1895, VI, 164.

Three cases of plastic surgery. ibid, 1896, VII, 25.

An experimental study of the thyroid gland of dogs with especial consideration of hypertrophy of this gland. Johns Hopkins Hosp. Reports, 1896, I, 372.

Operative treatment of gallstones. Maryland Med. Jour., 1896, XXXV, 101.

Rectal tuberculosis. ibid, 101

Compensatory hypertrophy of the thyroid gland. ibid, 1897, XXXVII, 67.

Remarks concerning gallstones and biliary surgery. Bull. Johns Hopkins Hosp., 1897, VIII, 31.

Inflated rubber cylinders for circular suture of the intestine. ibid, 1898, IX, 25.

Miniature hammers and the suture of the bile ducts. ibid, 67.

A clinical and histological study of certain adenocarcinomata of the breast. Trans. Am. Surg. Assoc., 1898, XVI, 114.

Bacteriology of cystitis. ibid, 50.

Concerning drainage and drainage tubes. ibid, 103.

The pancreatic ducts; action of pancreatic juice on the skin. ibid, 232.

Gunshot injury of the spine. Jour. Am. Med. Assoc., 1898, XXX, 1109.

Contribution to the surgery of the bile passages. Bull. Johns Hopkins Hosp., 1900, XI, 1.

The forceps of Laplace and intestinal anastomosis. ibid, 1899, X, 114.

Successful removal of a large foreign body from the head. Phila. Med. Jour., 1900, V, 4.

A contribution to the surgery of foreign bodies. Johns Hopkins Hosp. Reports, 1900, IX, 1047.

Excision of upper portion of right femur for tuberculosis of hip joint. Bull. Johns Hopkins Hosp., 1900, XI, 19.

Retrojection of bile into the pancreas, a cause of acute haemorrhagic pancreatitis. ibid, 1901, XII, 179.

Brief consideration of the cases of cancer of the breast treated at the Johns Hopkins Hospital since 1889. Trans. Am. Surg. Assoc., 1901, XIX, 26.

Bisection of large tumors as aid to enucleation. Maryland Med. Jour., 1901, XLIV, 316.

Local anaesthesia with weak solutions of cocaine. Trans. Am. Surg. Assoc., 1901, XIX, 293.

Remarks on 780 cases of hernia operated at the Johns Hopkins Hospital. ibid, 357.

Egg-sized gallstone of common bile duct; liver abscess. Bull. Johns Hopkins Hosp., 1902, XIII, 147.

A case which may point out a new disease of the lymph glands. Gaillard's Med. Jour., 1902, LXXVII, 217.

Closure of cystic duct after excision of gall-bladder. Bull. Johns Hopkins Hosp., 1902, XIII, 54.

The cure of the more difficult as well as the simpler inguinal ruptures. ibid, 1903, XIV, 208.

The X-Ray treatment of cancer. Maryland Med. Jour., 1903, XLVI, 282.

Pathology and treatment of benign tumors of bone with cyst formation. Bull. Johns Hopkins Hosp., 1904, XV, 262.

The training of the surgeon. ibid, 267.

Carcinoma preceded by a history of gastric ulcer. ibid, 347.

Partial occlusion of the aorta. ibid, 1905, XVI, 202.

Partial occlusion of blood vessels, especially of the abdominal aorta. ibid, 346.

The clinical features of thyroid hypertrophy. ibid, 288.

Results of the open air treatment of surgical tuberculosis. Amer. Med. Phila., 1905, X, 937.

Results of occlusion of aorta by metal bands. Trans. Sect. Surg. and Anat., Am. Med. Assoc., 1906, 587.

Hansman's plate for fracture of the femur. Maryland Med. Jour., 1906, XLIX, 280.

Blood vessel surgery and manual dexterity. Bull. Johns Hopkins Hosp., 1906, XVII, 237.

Experimental partial occlusion of arteries. Trans. South. Surg. and Gynaec. Assoc., 1906, XIX, 486.

Hypoparathyreosis, status parathyreoprivus and transplantation of the parathyroid glands. Am. Jour. Med. Sc., 1907, CXXXIV, 1.

Results of radical operations for the cure of carcinoma of the breast. Trans. Am. Surg. Assoc., 1907, XXV, 61.

Relation of goitre and chronic rheumatism, etc. Maryland Med. Jour., 1907, L, 72.

Preservation of the parathyroids during thyroidectomy. Trans. Am. Surg. Assoc., 1907, XXV, 60.

Surgical tetany and the parathyroids. Jour. Am. Med. Assoc., 1907, XLIX, 1243.

The parathyroid glandules. Their blood supply and their preservation in operations on the thyroid gland (with H. M. Evans). Ann. Surg., 1907, XLVI, 489.

Transplantation of parathyroid glands in dogs. Proc. Soc. Exp. Biol. and Med., 1908, V, 74.

Some results of recent experimental work on the parathyroids. Maryland Med. Jour., 1908, LI, 536.

Surgical tuberculosis and tuberculin. ibid, 32.

Auto and isotransplantation in dogs of the parathyroid glandules. Jour. Exp. Med., 1909, XI, 175.

Partial progressive and complete occlusion of aorta in dog by metal band. ibid, 373.

Clinical and experimental contributions to the surgery of the thorax. Trans. Am. Surg. Assoc., 1909, XXVII, 111.

A general consideration of the treatment of aneurysms of the main arteries. Bull. Med. and Chir. Faculty, 1909, I, 182.

The relation of the duration of goitre to changes in the thyroid. Trans. Am. Surg. Assoc., 1909, XXVII, 69.

The parathyroids and the operative treatment of the thyroid gland. ibid, 75.
Centripetal arterial transfusion. ibid, 85.
The isotransplantation of muscles in dogs. ibid, 308.
End-to-end suture of the intestine by a bulkhead method. ibid, 1910, XXVIII, 256.
Intratracheal insufflation, etc. Med. Record, 1910, LXXVII, 511.
Partial occlusion of large arteries by aluminum bands. Trans. Am. Surg. Assoc., 1910, XXVIII, 49.
Hepatico-duodenal anastomosis. ibid, 312.
Epithelkorperchen. Verh. Dtsch. Gesellsch. f. Chir. Berlin, 1911, XL, Theil 1, 45.
Non drainage of joints. Trans. South. Surg. and Gynaec. Assoc., 1911, XXIV, 234.
Report of a dog maintained in health by a parathyroid autograft. Jour. Exp. Med., 1912, XV, 205.
A bulkhead suture of the intestine. ibid, 216.
The effect of ligation of the common iliac artery on the circulation and function of the lower extremity. Bull. Johns Hopkins Hosp., 1912, XXIII, 191.
Developments in the skin grafting operation for mammary cancer. Trans. Am. Surg. Assoc., 1912, XXX, 287; also Jour. Am. Med. Assoc., 1913, LX, 416.
Hypertrophy of the thyroid gland; revision of experiments made 25 years ago. Proc. Soc. Exp. Biol. and Med., 1912-13, X, 111.
Partial occlusion of aorta by bands of fresh aorta and fascia lata. Trans. Am. Surg. Assoc., 1913, XXXI, 218.
Excision of both lobes of thyroid for the cure of Graves' disease. ibid, 319.
Preliminary ligation of thyroid arteries. ibid, 312.
Factors concerned in causing hypertrophy of the thyroid. Trans. Assoc. Am. Phys., 1913, XXVIII, 127.
Ligature and suture material. Also, an account of introduction of rubber gloves, gutta percha tissue and silver foil. Jour. Am. Med. Assoc., 1913, LX, 1119.
Significance of the thymus gland in Graves' disease. Harvey Lecture, 1913-14, Phila., 1915, IX, 224. Also, Bull. Johns Hopkins Hosp., 1914, XXV, 223.
Die Partielle Verschluss grosser arterian. Archiv. f. kl. Chir., Berlin, 1914, CV, 580.
A case of iliofemoral aneurysm. Jour. Am. Med. Assoc., 1914, LXIII, 207.
John Shaw Billings. Bull. Johns Hopkins Hosp., 1914, XXV, 249.
Dr. Tiffany's place in American Surgery. Bull. Med. and Chir. Faculty Maryland, 1913-14, VI, 131.
Results of X-ray treatment of thymus gland in Graves' disease. Bull. Johns Hopkins Hosp., 1915, XXVI, 55.
Elusive mobility of the breast in a case of retromammary cyst. ibid, 350.

A diagnostic sign of gelatinous carcinoma of the breast. Jour. Am. Med. Assoc., 1915, LXIV, 1653.

As to the cause of the dilatation of the subclavian artery in certain cases of cervical rib. Proc. Soc. Exp. Biol. and Med., 1915, XIII, 1. Also, Trans. Am. Surg. Assoc., 1916, XXXIV, 273.

Surgical and medical cures of hyperthyroidism. Bull. Johns Hopkins Hosp., 1915, XXVI, 59.

An experimental study of circumscribed dilatation of an artery immediately distal to a partially occluding band. Proc. Nat. Acad. Sc., 1918, IV, 204. Also, Jour. Exper. Med., 1916, XXIV, 271.

The ideal operation for aneurysm. Bull. Johns Hopkins Hosp., 1916, XXVII, 94.

Arterial dilation in arteriovenous fistula and in cases of cervical rib. Bull. Med. and Chir. Faculty Maryland, 1917, IX, 122.

The operative approach and mortality in acoustic tumors. Bull. Johns Hopkins Hosp., 1917, XXVIII, 239.

History and development of surgery with special reference to the thyroid. Bull. Med. and Chir. Faculty Maryland, 1918, X, 85.

Cylindrical dilatation of common carotid following partial occlusion of the innominate and ligation of the subclavian. Trans. Am. Surg. Assoc., 1918, XXXVI, 501.

The sinus-spud. Bull. Johns Hopkins Hosp., 1918, XXIX, 195.

Congenital arteriovenous and lymphatico-venous fistulae. Trans. Am. Surg. Assoc., 1919, XXXVII, 262.

The omission of drainage in common duct surgery. Jour. Am. Med. Assoc., 1919, LXXIII, 1897.

The operative story of goitre. Johns Hopkins Hosp. Reports, 1920, XIX, 71.

Self eventration of a large abdominal hygroma through a scalpel prick of the peritoneum. Bull. Johns Hopkins Hosp., 1920, XXXI, 13.

The upturned edge of the liver over an acutely distended, empyematous gall-bladder. ibid, 14.

A striking elevation of the temperature of the hand and forearm following the excision of a subclavian aneurysm. ibid, 219.

Ligation of the left subclavian artery. Johns Hopkins Hosp. Reports, 1921, XXI, 1.

An end-to-end anastomosis of the large intestine. Bull. Johns Hopkins Hosp., 1921, XXXII, 98.

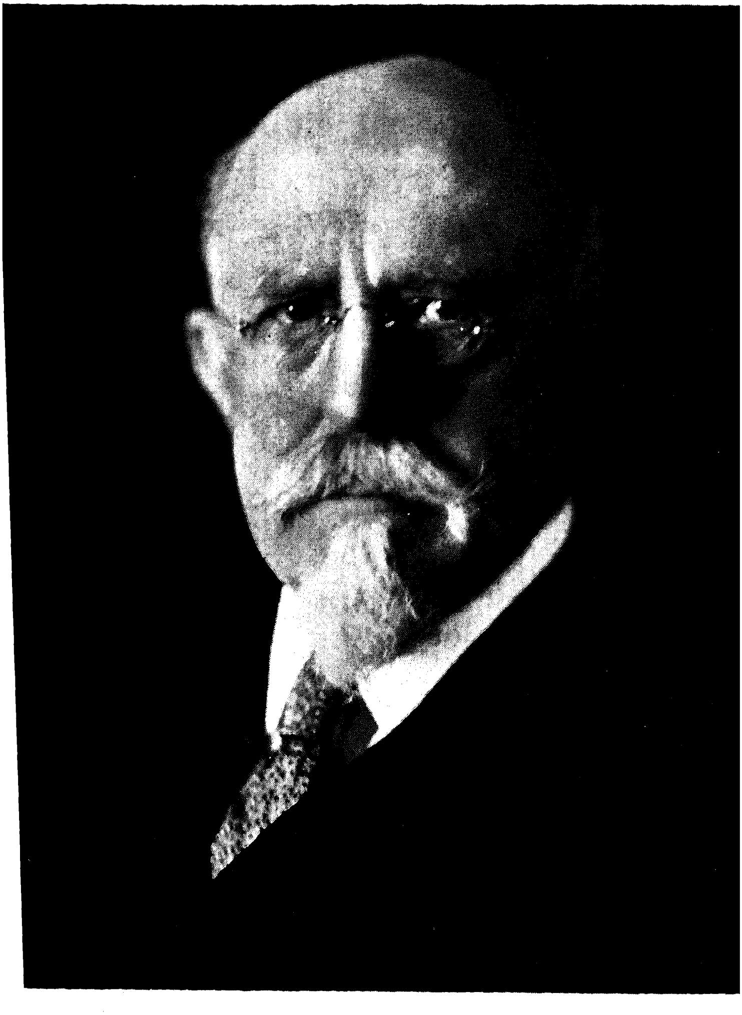
The swelling of the arm after operations for cancer of the breast. ibid, 309.

Ablation d'un aneurysme de la premiere portion de l'artere sousclaviere, etc., Lyon Chirurg., 1921, XVIII, 1.

Blind end circular suture of the large intestine. Ann. Surg., 1922, XXXVII, 356.

The effect on the walls of blood vessels of partially and completely occluding bands. Trans. Am. Surg. Assoc., 1922, XL, 201.

Centripetal arterial transfusion. ibid, 218.
Replantation of entire limbs without suture of vessels. ibid, 160. (With Reichert and Mont Reid.)
Surgical papers of William Stewart Halsted. Edited in two volumes by Walter C. Burket. The Johns Hopkins Press, 1924.
William Stewart Halsted, Surgeon. W. G. MacCallum, The Johns Hopkins Press, 1930.



John R. Freeman

NATIONAL ACADEMY OF SCIENCES

OF THE UNITED STATES OF AMERICA

BIOGRAPHICAL MEMOIRS

VOLUME XVII—EIGHTH MEMOIR

BIOGRAPHICAL MEMOIR

OF

JOHN RIPLEY FREEMAN

1855–1932

BY

VANNEVAR BUSH

PRESENTED TO THE ACADEMY AT THE AUTUMN MEETING, 1935

JOHN RIPLEY FREEMAN

1855–1932

BY VANNEVAR BUSH

John Ripley Freeman, distinguished here and abroad as a civil engineer, hydraulician and pioneering expert in fire prevention and control, was born on his father's farm, West Bridgton, Me., July 27, 1855, and died at his own home in Providence, R. I., October 6, 1932. His professional life of fifty-six years was crammed with useful and largely original work—eagerly undertaken, thoroughly and brilliantly completed—which won for him the respect and liking of colleagues, the loyalty of co-workers, and grateful public appreciation.

Fortunate in possessing a vigorous body and a penetrating mind, he used these talents with unremitting zest: there was no lost motion in the running of this rugged and nicely adjusted mechanism of muscle, heart and nerve, over which ruled a will tensed for sustained effort and an intelligence that united insight with precision and force. He set a stiff pace for others, but spared not himself. If he exacted hard stints from his helpers, he inspired them, too, by enthusiasm and example; in the midst of a demanding job he kept no working hours, and scarcely knew how to call a day a day. Though the pressure of the drive was relentless, he stayed in the van through the toughest going. And to these qualities of character—industry and leadership—a third was added, integrity.

A distinctive gift of Dr. Freeman's was engineering intuition. Without the full mathematical equipment available and necessary to engineers of the new generation, he could nevertheless arrive, as by constructive shorthand, at clear concepts and dependable results. This was by no means guesswork: it was rather a function of his critical faculty, by means of which he could quickly find the soft spots in an engineering paper and would center upon the essentials of any undertaking. Thoroughness, almost to the point of skepticism, forced him

to review and test the findings of predecessors and colleagues alike; he was unwilling to accept others' views at second hand.

It was Dr. Freeman's critical faculty that led him to note how far engineers had failed to give due weight, in construction work, to geological formations, and he became intimately acquainted with the problems of engineering geology. Again, criticism showed him, early in his career, the need of trying out the principles of hydraulics concretely in the laboratory, by the use of scale models. This made him the determined advocate of a national hydraulic laboratory to be devoted to such work. His arguments and plans resulted in the establishment of the River Hydraulic Laboratory at the Massachusetts Institute of Technology and the National Hydraulic Laboratory in connection with the U. S. Bureau of Standards. His views in this field also were influential in the design of the River Hydraulic Laboratory at Vicksburg, Miss., constructed by the U. S. Army Engineer Corps as an aid in its river and harbor work.

In his later life, under the spur of ruinous losses from earthquakes in Japan, in California and elsewhere, he undertook, successfully, to discover what construction changes, at what added cost, were necessary to safeguard buildings from such losses. In this research he displayed, as always, his conspicuous skill in assembling and ordering all pertinent information; so that one product of this effort was a compendium of fact and interpretation in the field of seismology which serves as an indispensable handbook. And by his generous initiative he brought from Japan one of the outstanding authorities on earthquakes and earthquake damage, that this expert's special knowledge might be made available to workers in this country.

Dr. Freeman's career was notable also for the extent and value of his public services, and for his generous and devoted support of professional education; so that to review the scope and importance of his studies and contributions in these fields is to marvel at the sustained productivity of the man no less than at the quality of the product.

Yet, quite apart from engineering, Dr. Freeman enjoyed, so to speak, a second life, a life of distinguished attainment in a

separate field. From 1896 to the end, as head of a large group of fire insurance companies whose policies covered industrial structures, he effected economies and devised safeguards in fire protection which gained for him an international name. Indeed he was wont to say that insurance was his vocation, engineering his avocation; and his working time was about equally divided between these broad groups of activity.

Except for photography, in which as an amateur he delighted to interest himself, Dr. Freeman had no hobbies. He had, in fact, no recreations except those which most men might have counted as another sort of work. His visits abroad were not all diversion, for his itinerary always included the principal places where research work in hydraulics or hydraulic construction was carried on, and especially those places where Freeman scholars were engaged upon studies of which the results were later to be brought back for the benefit of American engineers.

Extraordinary notice was taken of Dr. Freeman's accomplishments and a fine tribute to his personal character was paid when, on April 21, 1931,—only a little more than a year before his death,—a testimonial dinner was given in his honor at Providence, R. I., sponsored by the Providence Engineering Society. Here, even in his own lifetime, Dr. Freeman received, capping his many academic honors and scientific awards, a very personal and intimate recognition from every quarter into which his many-sided labors had extended. He was prophetic and unconventional in much of his thinking and his downright and straightforward habit, his forceful and convincing personality, and his unquestioned achievements, raised him to a position of prominence and broad influence that all could and did respect.

After attending the country schools in his home town, Freeman continued his preparatory education in the public schools of Portland, Me., and Lawrence, Mass. In 1872 he entered the Massachusetts Institute of Technology, from which he was graduated in 1876 as a Bachelor of Science, from the Department of Civil Engineering. He then entered the service of the Essex Company, a water power company of Lawrence, Mass., where he acted in a double capacity as principal assistant to the company and chief aid of Hiram F. Mills, the company's engineer. Mills was a gifted pioneer in hydraulics, and through him Freeman

was soon in intimate association with other leading engineers of the time, among whom were Charles S. Storrow, James B. Francis, Joseph P. Davis, and John C. Hoadley.

At the Providence testimonial dinner Dr. Freeman, responding to the presentation of a memorial gift, told of the benefits he had derived from knowing and working with such men. He referred to an address by former President Faunce of Brown University, the printed title of which was: "Temptations Upward." "I have been wonderfully fortunate," said Dr. Freeman, "in the way I happened to be situated so as to be tempted upward by the men with whom I was thrown in contact, particularly in my earlier years."

While with the Lawrence company Dr. Freeman profited by his personal work with Mr. Mills, who then had a varied consulting practice that included, besides water power projects, problems of foundations and of factory construction. This period was, in substance, a well-rounded apprenticeship of ten years' duration.

At the end of this time, namely in 1886, Dr. Freeman resigned and came to Boston, Mass., as Engineer and Special Inspector for the Associated Mutual Fire Insurance Companies. Here he began those studies and innovations in measures for fire prevention and control that were to make him famous in this industrial field. Reorganization of these companies' inspection service was one step toward greater efficiency and reduction of fire losses. Another was a series of experiments designed to improve and standardize fire-prevention apparatus. A third took the form of scientific investigation of the causes of fires. He presented to the American Society of Civil Engineers, for example, a paper on "Experiments Relating to the Hydraulics of Fire Streams," for which he received the Norman Medal of the Society in 1890, and another on "The Nozzle as an Accurate Water Meter," for which he received the Norman Medal in 1891.

"While in Boston," relates the same Society's memoir of Dr. Freeman, he "arranged to give one-half of his time to a consulting practice in water power, municipal water supply, and factory construction. There he also began his long career in public service, to which he gave so much of his life. He was a member of the Water Board of Winchester, Mass., where he made his home,

and in 1895 and 1896 he was Engineer Member of the Metropolitan Water Board of Massachusetts, which was then engaged in preparing plans for a development of a large additional water supply from the Nashua River for the Boston Metropolitan District."

In 1896 Dr. Freeman was chosen President and Treasurer of the Manufacturers' Mutual Fire Insurance Company and Associated Companies. The offices were in Providence, and he left Boston for Providence to take up this work, which was to be a major concern of his life until the end. Here his business gifts were brought into full play, to the great gain of policy-holders. Between 1896 and 1932 the business of his companies increased more than forty-fold, while losses were reduced to one-fourteenth of their amount in 1896 and returns to policy-holders in dividends rose to 96 per cent of the premiums. At the same time he continued his efforts to reduce loss of life and property through fire. Especially worthy of note were two writings of his during this period: "The Safeguarding of Life in Theatres" (1905) and a paper on "The Fire Protection of Cities," which was presented to the International Engineering Congress at San Francisco, Calif., in 1915.

Dr. Freeman was always deeply interested in city water supplies and his engagements on problems involving such supplies, as phrased in the memoir that accompanied the award of the John Fritz Medal, "included the greatest enterprises of a half century." In addition to the project for the Boston Metropolitan District already mentioned, certain others in a long list are outstanding. In 1899 he was invited to study water-supply problems of New York City. This resulted in a notable report and in an invitation to serve as chief engineer of the Department of Water Supply, Gas and Electricity, which he declined. He served as member of the Commission on Additional Water Supply of New York City. This was the board of three members, commonly referred to as the Burr-Hering-Freeman commission, which directed the building of the great Catskill Mountain water supply system. Dr. Freeman would not accept the post of chief engineer on this project, but all three members were consulting engineers and Dr. Freeman, who had been highly influential from its beginning, continued his services till his death. In 1907

and 1908 he was also senior consulting engineer to the New York State Water Supply Commission.

San Francisco, Los Angeles, San Diego, Mexico City, Baltimore, Md., Seattle, Wash., and Denver, Colo., were others of the leading cities in which Dr. Freeman's advice on water supply problems was sought and obtained. Among water storage projects which he studied, was one for a reservoir on the Sacondaga River, in the Adirondack region, New York, which has since been constructed.

Water power projects upon which he was consulted included the Massena development on the St. Lawrence River for the St. Lawrence Power Company and its successor, the Aluminum Company of America. He also aided the Aluminum Company in power developments on certain Southern rivers and on the design and construction of new smelting works at Niagara Falls, N. Y. He made investigations on power development for the Canadian Government in Alberta, Manitoba, and British Columbia, and designed dams for the Mexican Northern Power Company and for the Pacific Gas and Electric Company at Lake Spaulding, California. He designed and supervised the construction of a high masonry dam on the Missouri River at Holter, Mont.

"Not the least of Dr. Freeman's contributions in the broad field of hydraulic engineering," says the memoir of the American Society of Civil Engineers, "were those on problems of river control and navigation. Among his writings on these matters was a paper on 'Flood Control of The River Po in Italy,' which was presented at the meeting of the Society in June, 1928, and for which he received the J. James R. Croes Medal on January 21, 1931."

As chief engineer of the Charles River Dam Commission, of Massachusetts, Dr. Freeman prepared in 1903, a report recommending that the lower estuary of the river be converted into a fresh-water lake—the now familiar and much admired Charles River Basin. This report was an admirable example of Dr. Freeman's thoroughness, critical judgment and clear and cogent reasoning. The recommendations, in almost all particulars, were followed.

In the account of Dr. Freeman's work in the memoir of the American Society of Civil Engineers, appears the following:

"In 1904, he reported to the Massachusetts Metropolitan Park Commission on the improvement of the Mystic River and the improvement of the Fresh Pond marshes. In 1905, 1908, and 1915, Dr. Freeman was appointed by the President of the United States a member of Engineering Boards to report on a sea-level *versus* a lock canal and on problems of dam and lock foundations, and earth slides that blocked the Isthmus of Panama several times. From 1917 to 1920, he acted as consulting engineer to the Chinese Government on the improvement of the Grand Canal and the prevention of disastrous floods on the Yellow River and the Hwai River, organized a staff of engineers to investigate these problems, and went to China himself in 1919. Between 1924 and 1926, Mr. Freeman was a member of the Engineering Board of Review of the Sanitary District of Chicago and prepared a program for the regulation of the Great Lakes. His report on these matters included exhaustive studies of winter evaporation from the Great Lakes and of minor earth movements or tilting affecting the problem of lake levels."

As Dr. Freeman's professional pre-eminence was in hydraulic engineering, it is of particular interest to note and to emphasize his determining influence in bringing about the establishment of hydraulic laboratories in this country, as briefly set forth in the foregoing. He had been a member of the American Society of Civil Engineers for forty years when, as newly chosen president, he made an address at the annual convention of the Society at Portsmouth, N. H., on June 21, 1922, in which his initiative on this subject is traced to its very source. The address, covering 52 typewritten pages, is in its entirety a good illustration of Dr. Freeman's comprehensive method of dealing with his subject, in this case an outline history of progress in hydraulics. But, especially, it reveals that it was as early as 1912 that Dr. Freeman had dreamed his hydraulic laboratory dream. He said:

"For ten years past I have been thinking of the benefits that might come from a hydraulic laboratory, built on a large scale, in which sundry important observations could be made, and nine years ago [1913], I visited the New Flussbau Laboratorium of the Technische Hochschule at Dresden, Germany. Three years

ago, I urged the value of such a laboratory on a group of members of the Society gathered at lunch in San Francisco, Calif., urging that, if established at their great University of California, it would contribute greatly to the economic solution of some of the problems of the Sacramento River and of the problems presented by some of the torrential streams that at times rush down the Pacific delta cones. . . . On several occasions I have suggested the value of such a laboratory *somewhere* in the United States." He was led to believe, he added, "that *now is the time* to urge the importance of immediately constructing a National Hydraulic Laboratory, on a large scale, in some locality where it will be in a scientific atmosphere (for, in addition to many simple matters of experiment and observation, there are some very obscure phenomena of intricate hydrodynamics, colloidal physics, and other abstruse matters to be considered), which shall be at the service of whatever branch of the Government may need it. First, for a season, say, in the service of the River and Harbor Engineers; next, perhaps, of the Hydrographic Branch of the U. S. Geological Survey; next, possibly, for some months, in the hands of the Reclamation Service; and, next, perhaps, serving the Department of Agriculture; and sometimes serving a special purpose outside the Government service. Such a laboratory, operated in close parallel to studies on the real river, can be made to give a new impetus to several extremely important branches of hydraulic science, and give precise data which we lack in important fields."

Further on in this address Dr. Freeman sketched the work done in European hydraulic laboratories he had visited.

During later visits, in 1924, to hydraulic laboratories in Europe, Dr. Freeman proposed the compilation and publication of a German work in which these establishments should be described and their practice and achievements set forth. This suggestion was urged by him upon the engineers in charge—Professors Engels, de Thierry, Rehbock and Smrček—and upon Dr. Conrad Matschoss, Secretary of the Society of German Engineers, all of whom agreed to it. The result was the publication, in 1926, of "The Hydraulic Laboratories of Europe" ("Die Wasserbau Laboratorien Europas"), a work of 431 pages, for which Dr. Freeman himself wrote the introductory chapter. An

English translation of this volume, brought down to 1929, was published in that year. Additions had expanded it to 868 pages, and more than one-half the cost of translation and publication was borne by Dr. Freeman, as gracefully acknowledged by Professor de Thierry at the time of Dr. Freeman's death. This book, of which the English title is "Hydraulic Laboratory Practice," is referred to and used widely as a standard reference by workers in hydraulics.

The importance of Dr. Freeman's influence upon engineering education has been intimated at many places in the foregoing record. It is not, however, to be fully understood without more detailed references to his distinguished services in this field. Dr. Freeman was offered the Presidency of the Massachusetts Institute of Technology, and his declination was due solely to a conviction that his main strength lay rather in the professional and the business domains. Moved by like considerations, he twice declined invitations to serve at Harvard as professor of civil engineering. His only teaching activity was as lecturer on the subjects of hydraulics, and of fire protection and fireproof construction, at the Institute, during the years 1890-1902. And yet it may justly be said that his educational activity, both direct and indirect, was prodigious. His sponsorship of "Hydraulic Laboratory Practice," and his previously mentioned compilation on seismology, "Study of a Rational Basis for Earthquake Insurance"—a volume of 904 pages, called by a colleague an "Encyclopaedia of Seismology"—would in themselves, for example, prove his title to the name of educator; many others of his writings and reports would confirm it. But Dr. Freeman did far more than such studies could do to promote the extension of knowledge and to aid both students and teachers.

On October 11, 1893, Dr. Freeman was elected to membership on the Corporation of the Massachusetts Institute of Technology. From that time till the time of his death he served regularly and faithfully on Visiting and Advisory Committees. He was always especially interested in the Department of Civil Engineering and in work in hydraulics, to which he made such notable contributions. In 1912 he was in charge of the committee to investigate the interior arrangements of the new Institute buildings in Cambridge.

Again, Dr. Freeman contributed generously to technical education when in 1923 he gave $25,000 to each of three engineering societies—the American Society of Civil Engineers, the American Society of Mechanical Engineers, and the Boston Society of Civil Engineers—for travelling scholarships in hydraulics, open to young engineers and junior professors.

Through his interest in seismology, and his generosity, Dr. Freeman brought to this country as a lecturer, the distinguished Japanese seismologist already referred to, Kyoji Suyehiro.

Dr. Freeman's public services as consulting engineer, to which reference has been made, were supplemented by other public services. These are numbered by the Freeman memoir of the American Society of Civil Engineers in the following words:

". . . Dr. Freeman was active during the World War as a member of the National Advisory Committee for Aeronautics, and reported at that time on the Hog Island Shipyard. He was also a member of the Visiting Committee of the Bureau of Standards, Washington, D. C. In Providence, which became his home after 1896, he identified himself with many local activities. In 1911, he made a study of city planning for the east side of Providence, including new highways, parkways, and parks. He also carried on as a private venture a large real estate development of higher character in the vicinity of his home. He served for ten years as a Director of the Rhode Island Hospital Trust Company and of the National Bank of Commerce, in Providence; in 1904, he was a member of the Rhode Island Metropolitan Park Commission; and during the war, served as President of the Providence Gas Company."

At the testimonial dinner of April 21, 1931, the following telegram was read by U. S. Senator Felix Hebert of Rhode Island:

"The White House,
"Washington, April 9, 1931

"Honorable Felix Hebert,
Providence, Rhode Island
My Dear Senator Hebert:

"I deeply regret that public business prevents my attending the dinner being given to Mr. John R. Freeman. I would be glad if you would convey to Mr. Freeman's friends the high apprecia-

tion which I and every engineer hold, not only for Mr. Freeman's great technical accomplishments, but for his many public services.

"Yours faithfully,

"HERBERT HOOVER."

Dr. Freeman, in 1888, married Elizabeth Farwell Clark. They had six sons, Clarke, Hovey T., John R. Jr., Evert W., Roger M., and Nathaniel D., and one daughter, Mary Elizabeth, now Mrs. Mary Elizabeth Freeman Clifford. Roger M. Freeman and Nathaniel D. Freeman are deceased.

DEGREES AND HONORS

Bachelor of Science, Massachusetts Insitute of Technology, Department of Civil Engineering, Boston, Mass., June, 1876.
Elected Honorary Member Phi Beta Kappa at Brown University, 1901.
Doctor of Science, Brown University, 1904.
Doctor of Science, Tufts College, 1905.
Member National Academy of Sciences, 1918.
Doktor Ingenieur, Ehrenhalber, der Sächsischen Technischen Hochschule, Dresden, Germany, June, 1925.
Honorary Member, Marsaryk Academy of Works, Czecho-Slóvakia, 1926.
Doctor of Science, University of Pennsylvania, 1927.
Ehrenbürger (Honorary Member) der Badischen Technischen Hochschule, Karlsruhe, Germany, January, 1929.
Doctor of Science, Yale University, 1931.
Mitglied des Wissenschaftlichen Beirats des Forschungs-Institutes in München und Walchensee, Bavaria, Germany, January, 1931.
Fellow of the American Academy of Arts and Sciences.

MEDALS

Norman Medal of the American Society of Civil Engineers, November, 1890.
Norman Medal of the American Society of Civil Engineers, June, 1891.
Gold Medal of the American Society of Mechanical Engineers, December, 1923.
J. James R. Croes Medal of the American Society of Civil Engineers, 1931.
Awarded the John Fritz Medal posthumously in December, 1934.

RECIPIENTS OF THE JOHN R. FREEMAN TRAVELLING SCHOLARSHIP

American Society of Civil Engineers

Professor Lorenz G. Straub, Experimental Engineering Laboratories, University of Minnesota, Minneapolis, Minn.

Professor F. T. Mavis, University of Iowa, Iowa City, Iowa.
Professor M. P. O'Brien, 228 Mechanics Building, University of California, Berkeley, Calif.
Professor C. E. S. Bardsley, Missouri School of Mines and Metallurgy, University of Missouri, Box 88, Rolla, Mo.
Professor J. G. Woodburn, State College of Washington, Pullman, Wash.
Captain Hans Kramer, U. S. Engineer Office, Memphis, Tenn.
Mr. Herbert H. Wheaton, Fresno State College, Fresno, Calif.
Mr. Donald P. Barnes, 1596 Monte Vista Street, Pasadena, Calif.

American Society of Mechanical Engineers

Mr. Herbert N. Eaton, Bureau of Standards, Department of Commerce, Washington, D. C.
Professor Blake R. Van Leer, Dean of Engineering, University of Florida, Gainesville, Fla.
Professor Robert T. Knapp, California Institute of Technology, Pasadena, Calif.
Mr. Reginald Whitaker, U. S. Naval Torpedo Station, Newport, R. I.
Mr. G. Ross Lord, University of Toronto, Toronto, Ontario, Canada.
Captain Hugh Casey, U. S. Army, Corps of Engineers, Washington, D. C.

Boston Society of Civil Engineers

Professor K. C. Reynolds, Massachusetts Institute of Technology, Cambridge, Mass.
Mr. Samuel Schulits, U. S. Reclamation Bureau, Denver, Colo.
Mr. Clifford P. Kittredge, 815 Grosvenor Building, Providence, R. I.
Mr. L. L. DeFabritis, York Ice Company, York, Pa.
Mr. Leslie S. Hooper, Worcester Polytechnic Institute, Worcester, Mass.

BIBLIOGRAPHY

Broadway draw bridge, Boston, Mass. M. I. T. C. E. Dept. Thesis 1876. 49 pp.
Percolation through Embankments. Trans. Boston Soc. Civ. Engrs., June 20, 1888. (In Assoc. Eng. Soc. Jl. v. 7, 1888, pp. 489-494.)
Prudence in Pillar Designs. Trans. Boston Soc. Civ. Engrs., Sept. 18, 1889. (In Assoc. Eng. Soc. Jl. v. 8, 1889, pp. 549-552.)
Experiments relating to the Hydraulics of Fire Streams. (A research upon the height and character of jets of water thrown from fire nozzles of many kinds. Also upon the flow of water and loss of head in fire hose of various kinds, over a wide range of velocities.) (Received the Gold Medal of A. S. C. E.) Trans. A. S. C. E., v. 21, 1889, pp. 303-482.
Comparison of English and American Types of Factory Construction. Trans. Boston Soc. Civ. Engrs., read Sept. 17, 1890, Jl. Assoc. Eng Soc., v. 10, 1891, pp. 19-51.

The Nozzle as an Accurate Water Meter. (Received the Gold Medal of A. S. C. E.) Trans. A. S. C. E., v. 24, June, 1891, pp. 492-527.

The Arrangement of Hydrants and Water-Pipes for the Protection of a City against Fire. Jl. New England Water Works Assoc., v. 7, Sept. 1892, pp. 49-77.

The Bursting of the Portland, Maine, Reservoir. Report of investigation of cause. Jl. New England Water Works Assoc., v. 8, No. 3, 1893, March (pp. 148-154).

Construction of Reservoir Embankments. Remarks at the Meetings of the Boston Soc. of Civ. Engrs. held Sept. 20 and Oct. 18, 1893.

The Bursting of the Distributing Reservoir at Portland, Maine, August 6, 1893. Trans. Boston Soc. Civ. Engrs. Assoc. Eng. Soc. Jl., v. 13, 1894, pp. 148-153.

Report to the Town of Winchester, Mass., on the Improvement of Its Water Supply and Its Future Requirements. Town Reports, 1894.

James Bicheno Francis: a memoir. (In collaboration with Desmond Fitzgerald and J. P. Davis.) (In Assoc. Eng. Soc. Jl., v. 13, January, 1894, pp. 1-9.)

Hoisting Apparatus of the Canal Head Gates at Sewall's Falls, N. H. Trans. A. S. C. E., v. 32, Sept., 1894, pp. 278-294.

Description of a New Form of Canal Waste Weir. Trans., A. S. M. E., v. 15. June, 1894, pp. 669-684.

Report upon New York's water supply with particular reference to the need of procuring additional sources and their probable cost with works constructed under municipal ownership. Made to Bird S. Coler, Comptroller. N. Y. 1900. 587 pp. (Preliminary study of ground water sources of Long Island.)

Silas Whitcomb Holman, class of '76, M. I. T. Technology Review, v. 3, January, 1901, pp. 13-30.

Report (in collaboration with F. P. Stearns and J. H. Schuyler) on the Future Water Supply of Los Angeles, Calif., 1902.

New York's Need for Additional Water Supply. National Board of Fire Underwriters Annual Report, 1902, about 20 pp.

Construction Details, Jerome Park Reservoir, New York Water Supply. Report to the Aqueduct Commissioners (with Wm. H. Burr and Rudolph Hering), July 28, 1903, 16 pp.

Report of Commission on Additional Water Supply of City of New York (with W. H. Burr and Rudolph Hering). Nov. 30, 1903, N. Y. 1904, 15 + 980 pp.

Report of the Committee on Charles River Dam . . . to consider the advisability and feasibility of building a dam across the Charles River at or near Craigie Bridge. Boston State Printer, 1903, 579 pp.

Report to the Massachusetts Metropolitan Park Commission on the Improvement of the Upper Mystic River and Alewife Brook by means of tide gates and large drainage channels. September, 1904, 109 pp.

On Contemporary Technical Education. (An address at the installation of President Charles S. Howe at the Case School of Applied Science, Cleveland, Ohio, May 11, 1904.) Jl. Assoc. Eng. Soc. v. 33, No. 2, August, 1904, pp. 58-72.

On the Safeguarding of Life in Theatres: being a study from the standpoint of an engineer. (A comprehensive study of theatre fires, their causes and means of prevention.) N. Y. A. S. M. E. 1906, 106 pp. (A reprint.) Also printed in A. S. M. E. Trans., v. 27, 1905-06, pp. 71-170.

Reports relating to Providing an Additional Water Supply for the City of New York (with Wm. H. Burr and Rudolph Hering). A report to the Mayor and Board of Estimate, January, 1905, 36 pp.

Concerning the Proposed Alliance between the Massachusetts Institute of Technology and Harvard College. The Technology Review, May 4, 1905, 30 pp. (A reprint.) Also in Technology Review, May 4, 1905, v. 7, pp. 26-52.

Proposed Reservoirs on the Blackstone River. Report to a committee of mill owners, on river discharge, designs for dams, estimates of cost and many maps, tables and diagrams, October 30, 1906, about 30 pp.

Reports to the New York State Water Supply Commission on investigations relative to feasibility and cost of construction of great dams on difficult foundations for water storage, flood relief and power development on the Hudson River at Sacondaga, and on the Genesee River at Rochester, N. Y., with designs and estimates. Albany, N. Y., State Printers, February, 1908, 250 pp.

Lock or Sea Level? The Problem of the Panama Canal. The Lock Canal. The Outlook, v. 91, 1909, pp. 931-943. Also in the Congressional Record, 1909, 14 pp.

The Conservation of Water. An address at a joint meeting called by the four National Engineering Societies: A. S. C. E., A. S. M. E., A. I. M. E., and A. I. E. E., New York, March 24, 1909, 13 pp.

Water Supply of Baltimore, Md. (with F. P. Stearns) March 25, 1910, about 75 pp. with appendices.

Reports . . . relative to Improved Highways and Parkways for the East Side of Providence. (Reports on improved highways, parks and parkways for the East Side of Providence, R. I. A study in city planning, with detailed designs and estimates of cost, April, 1911.) 1912. 128 pp.

On the proposed use of a portion of the Hetch-Hetchy, Eleanor and Cherry Valleys . . . for the Water Supply of San Francisco, Calif., and neighboring cities. With especial reference to a supply from the Hetch-Hetchy Valley with location adapted for maximum water power development with detailed designs and estimates of cost. San Francisco, July, 1912, 401 pp.

The Fire Protection of Cities. A paper presented at a meeting of the International Engineering Congress, 1915, in San Francisco, Calif., September 20-25, 1915. 19 pp.

Hog Island Shipyard. Report to an investigating committee of the United States Senate, March, 1918, published in the Report of the Shipping Board Emergency Corporation, pp. 2355 to 2384.

The Grand Canal of China: addresses at a dinner given in honor of Mr. John R. Freeman by J. Ripley, and at a dinner given Mr. Freeman by their Excellencies, Chin Yun-P'eng and Hsiung Hsi-Ling . . . at the Navy Club, Peking, October 25, 1919. Tientsin North China Star. 1919. 67 pp. (In English and Chinese.)

Flood Problems in China. (A paper before the A. S. C. E. based on the writer's personal explorations and surveys along portions of the Yellow River, Hwai River, and the China Grand Canal, etc., including, also, tentative plan for flood relief in the Lower Hwai District.) Trans. A. S. C. E., v. 85, May, 1922, pp. 1405-1460.

Progress in Technical Education: Specifications for a College President, Remarks . . . at Technology Alumni Banquet . . . Washington, D. C., February 2, 1922. Technology Review, April, 1922. 20 pp., including biographical sketch of J. R. F. (A reprint.) Also in Technology Review, v. 24, 1922, pp. 173-187.

Address at the Annual Convention, Hotel Wentworth, near Portsmouth, N. H., June 21, 1922. (Presidential address, A. S. C. E. Subject: Recent progress in the development of the aims of the Society, and progress and development of hydraulic science from earliest times.) Proc. A. S. C. E., August, 1922. 28 pp. (A reprint.) Also in Proc. A. S. C. E., v. 48, 1922, pp. 1351-1380.

The Fundamental Problems of Hydroelectric Development. An address at a joint meeting of the A. S. C. E., the A. S. M. E., and the A. I. E. E., New York, December 5, 1923, 31 pp. (A reprint.) Also in Trans. A. S. M. E., v. 45, 1923, pp. 527-566.

The Need of a National Hydraulic Laboratory for the Solution of River Problems, etc. Trans. A. S. C. E., v. 87, 1924, pp. 1033-1097. Also same as a preprint. New Orleans A. S. C. E. 1923, 62 pp.

General Review of Current Practice in Water Power Production in America. A paper presented at the First World Power Conference held in London, July, 1924, 36 pp.

Report on the Water Supply of the City of San Diego, Calif., with estimates on available sources, studies of precipitation, storage, designs of dams, etc., for their development, and estimates of cost. A Municipal Report. May, 1923.

Taming the Mississippi. (A presentation of some of the most important flood problems of the Mississippi River, with special reference to the floods of 1922 and 1927.) The Outlook, v. 146, June 8 and 15, 1927, pp. 182-186; 219-222.

Sanitary District of Chicago. Engineering Board of Review on the Lake Lowering Controversy. (J. R. F., member.) Pt. 1. Recommendations including brief statement of findings and conclusions. 1924, 17 pp. Pt. 2. Technical bases for the Recommendations of the Board of Review. 1925, 109 pp.

The Regulation of the Great Lakes. A report to the Sanitary District of Chicago. (A comprehensive study of fluctuations in elevation and discharge, also of the rainfall, evaporation and run-off of the Great Lakes region in the Northern United States. Designs of structures for regulating the discharge and the elevations of Lakes Michigan, Huron and Erie are presented with estimates of cost. A particularly interesting study is that of the winter evaporation from the vast water surface which has no ice cover. Also a study of the earth tilt now going on in this region.) May, 1927, 565 pp.

Needed: More Science in Flood Control. (An address before the Faculty Club of the Massachusetts Institute of Technology.) The Technology Review, December, 1927. 8 pp. (A reprint.) Also in Technology Review, v. 30, 1927-28, pp. 95-102.

Po River flood-control works: some observations. Eng. News Record, v. 100, 1928, pp. 506-507.

Flood Control on the River Po in Italy. (A report of a recent tour of inspection and an historical review. It is shown that the reports that this river is constantly raising its bed by reason of the sediments carried and the confinement between levees, are erroneous.) Proc. A. S. C. E., v. 53, 1928, pp. 957-992. Author's closure on above. Proc. A. S. C. E., v. 55, 1929, pp. 1227-1231. Also in Trans. A. S. C. E., v. 94, 1930, pp. 161-196.

Hydraulic laboratory practice; comprising a translation, revised to 1929, of Die Wasserbaulaboratorien Europas, published in 1926 by Verein Deutscher Ingenieure, including also descriptions of other European and American laboratories and notes on the theory of experiments with models. N. Y. A. S. M. E., 1929, 868 pp.

Progress in Hydraulic Laboratory Research. Paper No. 767, 8 pp. World Engineering Congress, Tokyo, Japan, 1929. Proc. v. 14, Engineering Science, Pt. 2. pp. 313-320. Also in Association of Chinese and American Engrs. Jl., v. 10, 1929, pp. 40-49.

Genesis and Evolution. American Machinist, Special No., April 3, 1930, pp. 551-573. (Condensed history of A. S. M. E. by 17 living past presidents, including J. R. F., p. 555.)

Engineering Data Needed on Earthquake Motion, for Use in the Design of Earthquake-Resisting Structures. Bull. Seismological Society of America, June, 1930, v. 20, No. 2, pp. 67-86.

The Italian Earthquake of July 23, 1930. Bull. Seismological Society of America, v. 20, No. 4, December, 1930, pp. 1-24.

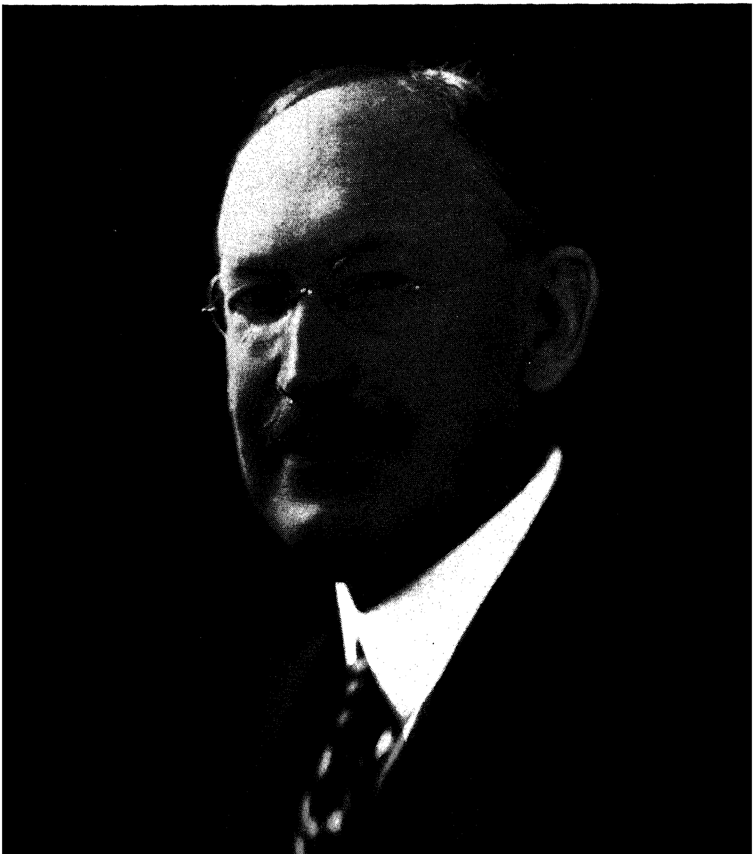
Ice as affecting power plants. Final report of Committee of Power Division. Proc. A. S. C. E., v. 56, 1930, pp. 743-759. Same in Trans. A. S. C. E. v. 95, 1931, pp. 1134-1150.

Design of National Hydraulic Laboratory . . . at the U. S. Bureau of Standards. Presented by Mr. Hebert. Senate document No. 208, 1930, 25 pp.

National Hydraulic Laboratory, Progress Report. Senate document No. 308, 1931, 16 pp.

Earthquake damage and earthquake insurance; studies of a rational basis for earthquake insurance; also studies of engineering data for earthquake-resisting construction. N. Y. McGraw-Hill, 1932, 904 pp. "Some afterthoughts of J. R. F. and a few notes from the Suyehiro lectures, January 18, 1932." 3 pp. attached to inside back cover.

Researches on Flow of Water in Pipes, Elbows and Tees. Description of an extensive series of very accurate experiments upon loss of head in wrought iron pipes of all commercial sizes from ¼ inch to 8 inches in diameter, at velocities from 0.5 to upward of 20 ft. per sec. Also upon smooth brass pipes from ½ inch to 4 inches in diameter. Also upon old and tuberculated pipe and pipe with an extremely rough lining of expanded metal lath. (In preparation, 1935.) (Mr. C. P. Kittredge, Freeman Eng. Corp., Providence, R. I., is continuing work on above.)



David White

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVII—NINTH MEMOIR

BIOGRAPHICAL MEMOIR

OF

DAVID WHITE

1862–1935

BY

CHARLES SCHUCHERT

PRESENTED TO THE ACADEMY AT THE AUTUMN MEETING, 1935

lection, which contained 100,000 Carboniferous specimens, chiefly plants. By the time the task was completed, Campbell informed the writer, White had thoroughly satisfied himself that fossil plants could be depended upon for chronology and in geologic field work. White told the Director of the Survey about his conclusions, but Walcott insisted that, before anything was published, White should thoroughly test his conclusions in the field, where they could be checked by superposition. Following out this plan, White was assigned to Campbell's field party in the spring of 1893, and they continued to work together until 1895. From lithologic evidence, the Coal Measures sequence as determined in Pennsylvania had previously been thought to extend in its entirety into the central and southern portions of the Appalachian trough. Campbell, being doubtful of this method, adopted in 1896 the correlations determined by White on the basis of the fossil plants that he had collected. Regarding this field work of White's, Campbell in a letter to the writer says: "We all shared White's enthusiasm, and I soon decided that I would rather trust to White's decisions than to my own tracing of formation outcrops."

Finally, White, Campbell, and Mendenhall published memoirs in which the results were decidedly different from those previously presented. The correlations of White have prevailed, based as they are on the correct paleobotanic succession, and the leading exponent of the earlier view magnanimously said in 1904: "There is no conflict between stratigraphy and paleobotany respecting the main horizons. The conflict was but apparent, and was due solely to hasty correlations by the early observers." In later years, White held that his reputation as a stratigraphic paleontologist was based mainly upon his studies of these Pottsville floras. He revolutionized the general conception according to which the Pottsville, Allegheny, Conemaugh, Monongahela, and Dunkard (Permian) were supposed to continue down the entire length of the Appalachian trough, proving that all the Pennsylvanian beds in Alabama, probably exceeding 10,000 feet in thickness, the entire Pennsylvanian of Tennessee, and all but a rather small part of the northeastern Kentucky coal field are of Pottsville age.

From describing the Pennsylvanian floras and formations,

White turned to the study of the origin and evolution of peats and coals, and soon became our foremost authority on this subject. From these deposits it was a natural step to the investigation of the origin and occurrence of petroleum, a study that led him to his famous hypothesis of the regional carbonization of Coal Measure strata, a theory which saved the oil companies millions of dollars that would otherwise have been spent in the drilling of dry wells. This "carbon ratio theory" is his greatest generalization, since it establishes a "dead line" beyond which oil pools will not be found. In the search for new oil territory in the years of the World War and afterward, White was of great service to his country. Finally, he was led to enter the field of geophysics, and he surprised the Fellows of the Geological Society of America in 1924 by taking, as the topic of his presidential address, "Gravity observations from the standpoint of the local geology." He was the first in this country to apply gravimetry to the detection of anticlinal structure.

Up to the summer of 1912, White's time was occupied almost entirely by research, and his results during that period are recorded in more than seventy-five reports, memoirs, and papers. However, he had served since 1907 as head of the Survey's Section of Eastern Coal Fields, and the breadth of interest and soundness of judgment there shown were fatal to his chances for uninterrupted research in so large an organization, and accordingly he was drafted in 1912 to become its Chief Geologist. For ten years he held this important post, and a strenuous decade it proved to be, because of the World War. But even during that period, when he was working late into the nights, he prepared more than a dozen scientific papers for publication. In response to his repeated urgings, he was relieved of direct administrative responsibility in 1922, with the expectation that his personal research could be immediately resumed, but soon other administrative calls were made by the Division of Geology and Geography of the National Research Council, of which he was general chairman for three years, as well as chairman of its Committee on Paleobotany from 1928 to 1934; and by the National Academy of Sciences, which he served as Home Secretary for eight years and as Vice-president

for two years. He also served as Curator of Paleobotany in the United States National Museum. In consequence, his return to research in 1922 was nominal only.

The year 1930 had been highly productive in printed papers, and in the summer and autumn of that year White spent about two months in the Grand Canyon of Arizona and elsewhere at altitudes that were not beneficial to him, with the result that early in 1931 he suffered partial paralysis, and during most of that year lay between life and death. His strong constitution and his superb courage and optimism, however, once more put him back at his desk. His physical endurance was greatly diminished, but his mental powers continued unimpaired. How active he was during the next four years is shown by sixteen published and unpublished papers. He was at his desk on February sixth, 1935, but before dawn of the next day he had passed away in his sleep, death resulting from cerebral hemorrhage.

In his time, White published a little over two hundred reports, memoirs, papers, and notes, some of which will be analyzed on following pages. These relate to Paleozoic plants and stratigraphy (about 80 titles), coal (27), petroleum (39), "carbon ratio theory" (6), climates (9), biographies (6), and miscellaneous (36). Of Paleozoic plants he described or listed upward of one thousand forms, and of new species he named between one and two hundred.

David White was a member of the Geological Society of America (president 1923), the Paleontological Society (president 1909), the Society of Economic Geologists, the American Institute of Mining and Metallurgical Engineers, the Washington Academy of Sciences (president 1914), the Geological Society of Washington (president 1920), the Botanical Society of America, and the National Parks Association. He was elected to the National Academy of Sciences in 1912; was a member of the American Philosophical Society and the American Academy of Arts and Sciences; and an honorary member of the American Association of Petroleum Geologists, the London Institute of Petroleum Technologists, the Société Géologique de Belgique, and the Geological Society of China. He served at various times on more than twenty important committees of the National

Academy of Sciences, the National Research Council, and scientific societies.

He received the honorary degree of Doctor of Science from the Universities of Rochester and Cincinnati in 1924 and from Williams College the following year.

He was honored by the National Academy of Sciences with the award of its Mary Clark Thompson and Walcott gold medals, and by the Society of Economic Geologists with its Penrose gold medal; and in 1934 he was presented with the Boverton Redwood medal of the Institute of Petroleum Technologists of London.

We may well agree with Professor Berry's appraisal:

"No geologist of his time had a wider influence on the scientific life of the nation, or took a more active part in that of its capital."

ANCESTRY AND TRAINING

Charles David White was so christened at the wish of his mother, but from 1886 onward he preferred to be known simply as David White, that name being taken from his grandfather, Colonel David White (1785-1861), a pioneer and frontiersman, and a man of strong and somewhat eccentric character. His father, Asa Kendrick White (1817-1883), was born at Heath in northwestern Massachusetts, and later settled on a farm near Palmyra, New York. He was a descendant, through six removes, of John White (1602-1673), of South Petherton, Somersetshire, England, who, with his wife, Jean West, and their six children, came to New England and settled in Wenham (part of Salem) in 1638-1639. Miss Flora White of Plover Hill Farm, Heath, informed the writer that the White family was a virile one, producing farmers, educators, clergymen, and public officials, and has undergone but little change in characteristics and interests during the twelve generations since Thomas White, who died in England in 1549.

David White's mother was Elvira Foster (1820-1880), daughter of Hiram Foster (1794-1880) and Nancy Reeves. Her paternal line goes back through six generations to Christopher Foster, who sailed from London for America on June 17, 1635, with his wife and three children, was made a freeman

at Boston in 1637, and in 1651 removed to Southampton, Long Island, where he was town clerk for thirty-two years. The Foster family is likewise one of energy and integrity.

David White was born July 1, 1862, on his father's farm in Palmyra township, Wayne County, New York, one mile south of the Marion town line on the road from Marion to East Palmyra. He was the youngest child of eight, six brothers and two sisters, all but one of whom attained the age of sixty or more. The family was Presbyterian, members of the church in East Palmyra. In Palmyra he attended the country school, in which at times an older brother or sister was a teacher. When he was eight or nine years old, the region received some hundreds of immigrants from Holland, among whom was Daniel Van Cruyningham, who worked as a hired man on the White farm but later graduated from the State Normal School and finally became principal of the Marion Collegiate Institute where David was receiving his college preparation. It was this man's wide intelligence and deep interest in the sciences that brought David, so he tells us, to the study of the flowering plants of the region and developed in him a deep interest in botany. One of his fellow students relates that David was a very tall, slender youth, who "always blushed as he arose to recite," that from the first he was considered an excellent student, and that as time passed he became popular with his classmates and the faculty.

Graduating from the Institute at the age of eighteen with much more Latin, Greek, and Trigonometry than was required for college entrance, White worked on the farm for two summers and taught school during the winters. Then, winning a county competitive scholarship at Cornell, he entered upon his college work in 1882. With the desire for learning implanted by his mother and a keen zest for science developed by Principal Van Cruyningham, he found in Cornell "most favorable conditions for growth in the liberal and stimulating atmosphere." The course pursued was then called Natural History, and included Botany. It required endless laboratory work of various kinds, leaving almost no time for athletics. The day was saved, however, by compulsory military drill for the first two years, to which White always acknowledged great indebted-

ness for the health and the erectness of stature so characteristic of him all through life. In the same class was Robert T. Hill, of Texas; both took the same courses, both became members of the United States Geological Survey after graduation, and both found their wives at Cornell!

White's study of Geology started in his sophomore year, with a general course given by Professor Samuel Gardner Williams. The next year he drifted into the classes of the widely known Professor Henry Shaler Williams, all of whose courses in Paleontology he pursued. At that time Doctor Charles S. Prosser, "a man of the highest personal character and scientific ideals," was laboratory instructor and assistant in the study of the Devonian invertebrate collections, to which the students of Paleontology were assigned for training. During field work with Prosser, White gathered numerous plantlike remains and in these he became particularly interested because of his love of systematic botany. Accordingly, when it became time to prepare the thesis then required for a bachelor's degree in science, he chose to make a thorough historical and systematic review of *Ptilophyton vanuxemi,* of which he had three thousand specimens collected from the shaly flags beneath the University campus.

This unpublished thesis, entitled "On the nature and systematic classification of Ptilophyton Vanuxemi," was loaned to the writer by the Cornell University Library. It consists of forty-five typewritten pages, with fifteen excellent pencil drawings of the fossils, made by White himself. This was his first attempt at scientific writing, and it shows that when he was twenty-three years old his methods of study and his style of presentation were already about as well developed as in later years. Even in those youthful years, he did not mind entering into a controversy with two of the paleontologic giants of that time, and we find him saying of *Ptilophyton vanuxemi:*

"It is evident that its present systematic classification is based principally on Morphology. Such being the case, it is not improbable that, paradoxical as it may seem, the species is still in a state of transition or migration; and, indeed, we do find it passing from one genus to another, disregarding all family ties, and vaulting from the animal to the vegetable kingdom, or from

the vegetable to the animal kingdom, until we are uncertain whether it will turn up tomorrow morning devouring animalcules and small crustaceans as *plumulina plumaria,* or dreamily undulating in the crystal depths of ocean as *Ptilophyton vanuxemi.*"

In the end, he agreed neither with Hall, who maintained that *Plumulina plumaria* was a marine animal, nor with Dawson, who held that *Ptilophyton vanuxemi* was a land plant. In 1896, White returned to this study in a paper on "The structure and relations of Buthograptus, Plumulina and Ptilophyton from the North American Paleozoic," and then concluded that all of these are marine algæ related to the seaweeds.

In his junior year, White's father died, and, having almost no money, he borrowed a little from a friend, and with free tuition from his scholarship and with further money received for the teaching of elementary free-hand drawing, he got together the funds necessary to continue his course. He had unconsciously prepared himself for this teaching—and for still greater things to come—by taking free-hand drawing in his freshman year and by practise gained in the botanical and zoological laboratories.

The fifteen drawings made by White for his thesis kindled the interest of Henry Shaler Williams, with the result that when Lester F. Ward, of the United States Geological Survey, wrote to Williams to know if he had a student who could make "accurate if not creditable" drawings of fossil leaves, such as he needed in a study of the Laramie and Fort Union floras, Williams immediately recommended White. The latter started work for Ward in Washington on May 16, 1886; and was officially appointed to the Survey the following October. A vista of life now lay open before him, and his was to be "the quenchless spirit of the inveterate explorer."

With the assurance of permanent work ahead, White married, on February 2, 1888, Mary Elizabeth Houghton, of Worcester, Massachusetts. She also is of Colonial stock. Before their marriage she had been a student at Cornell, taking special courses in literature and history. His meeting with her at Cornell, White always considered the "greatest good fortune of my life," and to her he still remains a "knight without fear and

without reproach." They had no children, but the lives of many young people have been enriched by their unconscious influence.

WHITE THE MAN

In appearance, David White was of commanding figure, six feet two inches tall, of an average weight of one hundred and eighty pounds, his blue eyes and blonde complexion bearing distinct evidence of his direct descent from Anglo-Saxon stock. He was ever alert and smiling. He met people easily, with ready and even voluble speech, and he possessed a charm of manner that made him a delightful companion, at home, in the office, or in the field. His sense of humor was subtle and delicate, often showing itself in sudden and evanescent flashes.

The instinct to help others seems to have been one of White's most deep-seated characteristics. It went beyond a willingness to lend a sympathetic ear, and sought at once for practical action. In recent years, he had come to be known as a special friend to the many expatriated Russians in this country, and he explained this interest by saying that he believed theirs had been one of the heaviest burdens left by the World War and that therefore they needed help most. At the end of his term of service as Chief Geologist, his old comrade Campbell said to him at a testimonial reception:

"We all wish to show you our regard and affection which we feel for you as our Chief for ten of the most eventful years of the Survey's existence. We appreciate your unselfish devotion to duty as Chief Geologist, your helpful spirit of cooperation in all scientific matters, and your strict justice and impartiality towards us all of the Geologic Branch, but above all considerations of a technical or scientific character, we value most highly your spirit of love and goodwill for each and every member of the Branch. You have welded us together, as never before, into one large family and inspired us with the desire to do unto others as we would have them do unto us."

Mendenhall relates that White preferred to remain a government geologist to the end, even when offers came to him to enter the commercial field at several times the modest salary which the government pays its scientific leaders. In the nineties, the writer has been told, while White was doing work in the

anthracite region, he noted that the lay of the rocks on one side of a valley, where coal was being abundantly mined, indicated synclinal structure. This being so, and if no faulting intervened, the coal beds should be repeated on the other side of the valley. Crossing over to test his conclusions, he saw that he was correct, and that here were buried millions of tons of anthracite unknown to the coal operators. What should he do? Resign from the Survey and turn real-estate promoter, or return to Washington and tell the Director of his discovery? He chose the latter alternative, and the facts were eventually published by the Survey. So White, preferring to remain loyal to the discovery of scientific truth, missed being a millionaire—a story the writer told to each succeeding class of his students as an example of the true spirit of scientific loyalty.

Mendenhall in his memorial says:

"White was given neither to underappreciation nor to overappreciation of self, he was wholesomely lacking in self-consciousness and always looked outward and forward, never inward or back. . . . In his philosophy life consisted wholly of opportunities to be made the most of, never of limitations to mourn over. . . . There was no resisting the infectiousness of his spirit."

Small wonder, with this combination of qualities, that David White was, as Berry says, "affectionately known to an incredibly large circle of friends and admirers."

WHITE AND GEOLOGIC CLIMATES

Some months after White joined the Survey, he began a compilation of the literature relating to Paleobotany, and a catalogue of the genera and species of fossil plants. Searching thus through the literature, he was led to write his first scientific publication, "Carboniferous glaciation in the southern and eastern hemispheres" (1889), a review that is written in a fluent style, marshaling the literature on a very interesting subject as if by a practised hand, and giving the status of the Glossopteris flora and of what is now called the Permian ice age of the Southern Hemisphere.

In subsequent years White wrote eight other papers on ancient climates, and made incidental remarks about this subject

in many others. His second contribution of this nature was a joint effort with Knowlton, "Evidences of paleobotany as to geological climate" (1910). In his "Upper Paleozoic climate as indicated by fossil plants" (1925), he says that the late Devonian floras "were not highly diversified" but were "relatively highly organized," and remarkable for their wide distribution. The early Mississippian flora ranged even within the Arctic Circle, but the floras of the latter part of this period are not known to have been luxuriant, and they testify at times to aridity or semiaridity. In early Upper Carboniferous times there was a very rapid differentiation of land plants out of a few genera. In the middle and upper Pottsville (Westphalian) occurs "the most luxuriant and highly elaborated land vegetation of the Paleozoic era," at a time when there was maximum equability of climate over most of the earth. Later (in Allegheny time) seasonal changes set in, and in the Conemaugh and Monongahela there is "fairly clear evidence of lack of uniformity of distribution in rainfall throughout the year."

The Permian flora of Europe and North America shows

"signs of generally less equability and, in particular, of seasonal variation in climate, with clear evidence of deficiency of moisture in many regions. . . . The coming of dry seasons, and possibly of irregular periods of deficient rainfall in latest Pennsylvanian and especially in Permian time, led to the ascendancy of the coniferous stock. . . .

"Relative equability and mildness of climate and great latitudinal range of climate in relative uniformity are, geologically speaking, normal. . . . On the other hand, great climatic differentiation and variability, both seasonal and geographic, are abnormal, and are, I believe, confined for the most part to periods of diastrophic revolution, such as that in which we live" (pp. 471-473).

That diastrophism and the resulting geographic alterations are the main causation of marked climatic change is more fully stated in "Some cold waves of geologic history" (1926) and in "Geologic factors affecting and possibly controlling Pleistocene ice sheet development in North America" (1926). White thinks that the cooling was due to

"changes of level of the land, great reduction of the epicontinental seas, especially in the temperate and higher latitudes, the

expansion of the continental surfaces, the corresponding differences in sub-oceanic topography, and the changes in ocean currents, air currents, rainfall and temperatures consequent to the changes in the land and water" (p. 69).

WHITE AS PALEOBOTANIST AND STRATIGRAPHER

In the summer of 1888, White made a collection of fossils, on his own account, at Gay Head off southern Massachusetts. Leaves, wood, invertebrates, and bones had been collected at this locality and written about ever since 1786, but since nearly all of the fossils had been picked up loose on the beach, geologists differed greatly as to the age of the strata. Most authors referred the beds to the Miocene, although some thought they saw Cretaceous fossils. After much persistent digging, White shipped to Washington "five barrels of very excellent material," nearly all of which he had taken out of definite horizons. On these he based his first stratigraphic paper, "On Cretaceous plants from Martha's Vineyard" (1890), which was illustrated by his own drawings. He concludes that the flora has "archaic types . . . unlike any that have yet been described." The relation of the Gay Head flora he found to be with that of the Middle Cretaceous (Cenomanian) of Greenland rather than with that of the Dakota group, and the plant assemblage is "largely identical with the flora of the Amboy clays." This paper was presented, with lantern slides, before the New York meeting of the Geological Society of America, with the great James Hall as presiding officer. In the *Bulletin* of the Society, we note that John S. Newberry, then the authority on Lower Cretaceous floras, commented that there could be no doubt about the Gay Head plants representing the Amboy clays and being of Middle Cretaceous age. Ward, White's chief at Washington, also agreed to the reference of the lower strata of Gay Head to the Cretaceous; when the paper appeared in print, Ward reviewed it in *Public Opinion*, and in a letter to the editors said:

"I am particular to have you know that the paper is wholly his [White's] own, and that I was unacquainted with its nature until I read of it in print. I have rarely enjoyed a more agreeable or complete surprise."

These high appraisals from leaders in Paleobotany must have pleased White and given him assurance for future work.

About 1892, a member of the Geological Survey of Missouri collected interesting plants from the Upper Carboniferous outliers flanking the Ozark uplift, and urged their prompt study, with the result that White was detailed by Ward to examine these plants not only in the laboratory but in the field as well, and to report on the findings. It was this detail by Ward that started White officially on his life work, namely, a thorough study of the Carboniferous floras of the United States. His first report was entitled "Flora of the outlying Carboniferous basins of southwestern Missouri" (1893), a work of 139 pages. The task came to full fruition in the memoir, "Fossil flora of the lower Coal Measures of Missouri" (1899), a monumental volume with 467 pages of text and 73 plates of plant illustrations.

In his "Age of the lower coals of Henry County, Missouri" (1897), White arrives at the following interesting results:

"The geographic distribution of the Mesocarboniferous floras throughout . . . Europe and Asia and North America . . . apparently indicate[s] an almost incredible uniformity in climate over the northern hemisphere during that period" and necessitates also "the assumption of such intercontinental relations and conditions as to furnish wonderful facilities for the exceedingly rapid, almost simultaneous, distribution of the genera and species" (pp. 302-303).

In 1904, White published his most philosophic paper, dealing with the stratigraphy of the Pottsville series throughout the Appalachian geosyncline ("Deposition of the Appalachian Pottsville"). The thickness is shown to be variable throughout the basin, being upward of 10,000 feet in Alabama, with the thickest deposits along the east side of the trough. The oldest Pottsville occurs on the West Virginia-Maryland-Virginia boundary, with the sedimentation spreading from here to the west and to the south (more quickly), and overlapping northward; in the bituminous region of Pennsylvania, Ohio, and northwestern West Virginia, there is no lower Pottsville at all.

White contemplated extensive monographs on the Pottsville and Mississippian floras, but these plans all had to be laid aside

when he became Chief Geologist in the Survey. This necessity he always viewed "with very deep regret." The manuscript in hand, Director Mendenhall told the writer, consists of more than two thousand pages of systematic descriptions of over two hundred species of fossil plants, about seventy-five plates of illustrations, chiefly drawings, and over five hundred unmounted photographs. The Survey hopes to bring this work up to date and to publish it. Another monograph was in preparation on the Pottsville flora of Illinois; on it White did much work during the last three years of his life, and the Illinois Survey expects to publish it also. Still a third monograph, on the Pocono floras, is not so well advanced, but may come to publication.

In July, 1897, the writer and White accompanied Peary to western Greenland on the Newfoundland whaling ship, "Hope." The purpose of the expedition was to bring back a thirty-ton meteorite, now one of the most significant exhibits in the American Museum of Natural History. The two paleontologists were sent by the Smithsonian Institution, with instructions to spend the short open season of six weeks in collecting fossils, chiefly plants, which had long been known to occur in the Cretaceous and Cenozoic deposits of Disko Island and Nugsuak Peninsula. The results of their collecting were described in 1898.

On the return from Greenland, White and the writer left the ship at Sydney and proceeded to St. John, New Brunswick, to call on Doctor G. F. Matthew and to see the "Devonian" floras of the region, which were kept with the collections of the local natural history society. White was soon convinced, as he had previously surmised from the literature, that these plants are in reality of Upper Carboniferous time. This view had been set forth much earlier by Geinitz and by Kidston. Nevertheless, the Canadian Geological Survey continued to map the Carboniferous formations of the Bay of Fundy region as Middle Devonian. White published a strong protest ("Some palaeobotanical aspects of the Upper Palaeozoic in Nova Scotia," (1901), showing that the Horton flora is of Lower Carboniferous (Pocono) time, while those of the Riversdale, Mackays Head, and Harrington formations are of Upper Cariboniferous (Millstone Grit) age; and in "Stratigraphy versus paleontology

in Nova Scotia" (1902) he stated that "over sixty percent of the valid plant species found at St. John [in the Fern Ledges] are also in hand from the Pottsville in the Appalachian trough."

White also wrote many papers on Permian, Devonian, and even Ordovician plants and stratigraphy. In his "Summary of fossil plants recorded from the Upper Carboniferous and Permian formations of Kansas" (1903), he for the first time uses the term Permian in the title of a paper, and records that in the Marion formation he finds plants "more nearly typical and characteristic of the Permian than any flora that I have yet seen from any other formation in the United States."

In 1904, he took up the subject of the Permian elements in the Dunkard flora, and states that of the 107 plant species he has seen, 22 are from the older Coal Measures of America and 28 are of the same age or of Permian age in Europe. In 1880, Fontaine and I. C. White had referred the entire Dunkard to the Permian, but David White regarded the strata below the lower Washington limestone as older than the Permian, while the higher part of the Dunkard, with *Callipteris,* he held to be equivalent to the Rotliegende of Germany. In 1926, he drew the boundary above the Waynesburg coal.

Previous to 1907, White had been studying the Permian Glossopteris flora of Brazil for I. C. White's "Relatorio Final," which was published in 1908, but a résumé of his results appeared the year before, in a paper called "Permo-Carboniferous climatic changes in South America." Both these studies are among the most important of those made by White. The Glossopteris flora of Brazil, with forty species, is correlated with that of the Talchir-Karharbari series of the Indian Peninsula. In the final quarto, White says that the

"cosmopolitan character and uniformity in distribution [of the Upper Carboniferous floras] forbid the admission of a glacial epoch between the base of the upper Carboniferous and the close of the upper Coal Measures, which marks the disappearance of many of the Coal Measures types. . . . For my own part, I am strongly disposed to regard the glaciation and approximate date of origin of the Gangamopteris [= Glossopteris] flora as not earlier than the orogenic movements and floral changes which ushered in the Permian" (p. 397).

One of White's most valuable papers, "Permian of western America from the paleobotanical standpoint" (1924), gives a review of the Permian throughout western North America. The Mid-Continent area of Kansas-Nebraska has "probably the most uninterrupted and complete Permian-Pennsylvanian section in all western America," he says in this article. The whole of the Council Grove formation is placed in the Permian, and the Neva limestone is regarded as making the base of the Permian system.

White's memoir on the Permian flora of the Hermit shale in the Grand Canyon (1929) is his most philosophic floral and environmental study, and is an indication of what he might have produced in more abundance had he not been bound down by administrative work. The Supai formation, long believed to be of Upper Carboniferous age, is here shown to belong to the Permian system. The Hermit flora "is largely unlike any flora known from the Lower Permian or the basal Upper Permian of any other part of the world;" no part of it is earlier than the Upper Rotliegende, and it is a heralding Zechstein assemblage.

His paper on "Some features of the American Permian" was presented to the Sixteenth International Geological Congress held in Washington in 1933, and reprints were published in 1934.

WHITE'S WORK ON THE NATURE OF COAL AND PETROLEUM

White's interest in the origin of coals began in 1893 with his field studies of fossil plants which he gathered at the coal mines, mainly in the Appalachian and the Eastern Interior regions. His special study in 1906 of the bedding conditions in a large number of coal fields of different ages in the east and west showed conclusively that ordinary coals were derived from woody terrestrial or carbohydrate tissues. He wrote at least twenty-seven papers on the origin of coal, beginning with a short note in 1907. In 1908, he defines coal as "a stratified carbonaceous deposit of first-hand organic débris in which the vegetable elements greatly predominate." The American coals were formed in situ under water on low lands, in peat swamps developed over old soils replete with roots of plants.

His most comprehensive and detailed report is "The origin of coal" (1913), a joint paper with Thiessen. Here he considers the geological relations and physiographic conditions attending the formation of coal, the rate of deposition, and the regional metamorphism. Coals are formed, he says, under

"(1) general mildness of temperature, approaching in most cases tropical or subtropical; (2) conspicuous equability or approximation to uniformity of climatic conditions, which, with a few exceptions, appear to have lacked cold winters or severe frosts; (3) a generally high humidity, the rainfall being from moderately heavy to very heavy and fairly well distributed through the year, though in many cases there is evidence of the occurrence of dry periods, which, however, seem ordinarily to have been comparatively short and not severe; (4) an amazingly wide geographical distribution of these genial and equable climates" (p. 68). Plants in swamps are reduced to coal by "(1) the biochemical process; and (2) the dynamochemical process" (p. 91).

In 1925, White returned to the theory of coal making in "Environmental conditions of deposition of coal." He does not subscribe to the popular idea that "mineral charcoal," the "mother of coal," or fusain, is of forest-fire origin and was later washed into the coal swamps, but holds that it is wood oxidized in the swamps while they were drying out under seasonal atmospheric exposure. The amount of fusain is so great and it is so variable in occurrence, he says, that it could not have been brought in by inwash from areas of forest fire without the accompaniment of great amounts of muds, which are not as a rule present where fusain is commonest.

As Chief Geologist of the Federal Survey, White became actively interested in the origin and nature of petroleum, and particularly in its regional distribution, and on these topics he wrote no fewer than forty-five papers. What he did during the years of the World War and afterward in directing the work of the Survey in the search for oil and gas, and in the elimination of waste in drilling, is well told by Miser in his memorial, and accordingly the subject need not be treated fully here.

In 1926, White brought together, for the *Treatise on Sedimentation* published by the National Research Council under the editorship of W. H. Twenhofel, the best account extant of

the carbonaceous sediments, devoting fifty pages (eighty in the second edition, 1932) to their occurrence, sources, geochemical and dynamic changes, and other topics.

In "A source of hydrocarbons in the Ordovician" (1906), the Plattville shale of Wisconsin is shown to have about 30 per cent of volatile matter, composed of unicellular pelagic algæ, which appear to be related to living Protococcales. Such deposits are the probable source beds for the petroleum and gas now found in Paleozoic formations.

White's most noteworthy economic paper is "Outstanding features of petroleum development in America" (1935). In this Congressional Document, much of the gloom of earlier estimates as to the amount of petroleum still in the rocks is dispelled. "The aims of the wartime estimates of the country's petroleum reserves were educative," he says, and "the warning forecasts were designed to shatter the complacent obsession that the United States 'has all the oil it will ever need.' "

Another of his striking papers is "Effects of geophysical factors on the evolution of oil and coal" (1935). Petroleum, he says, is the joint product of

"(1) sedimentary deposits of organic mother substances of somewhat variable composition; (2) biochemical change of the mother substances, varying in kind and extent with the composition of the original organic matter and the conditions of deposition; and (3) geochemical changes which take place underground in the course of time under (4) geophysical influences, and which probably vary with the ratios of pressure, temperature, and time. Further, as found the oil may have been modified by leakage of its lighter components; by contamination; by reaction with associated inorganic as well as organic substances; by oxidation, and by filtration (pp. 309-310).

"The progressive carbonisation of the coal on a regional scale in any direction, accompanied as it is by progressive dehydration, lithification, refinement of cleavage, and increase of calorific value, represents incipient metamorphism; . . . it must be due to progressive geochemical change induced or even controlled by geodynamic influences, and . . . it embraces the essential features of the evolution of the deposit from the rank of peat, at which bacterial action is assumed to have been suspended, to the final graphitic residues and fixed gases if the process has gone far enough" (p. 301).

White's "Graphic methods of representing the regional metamorphism of coals" (1909) and his "Regional devolatilization of coal" (1910) are heralds of what has come to be known as his "carbon ratio theory"—that of the "oil dead line"—which is believed to be his greatest service in the field of economic geology. In 1909, he exhibited a contoured isocarb map of a portion of the Appalachian region, showing the degree of devolatilization resulting in the fixed carbon ratios of coal (free of ash and moisture) as one passes eastward from the western margin of the coal field (60 per cent about Pittsburgh) to the anthracite region, where it is 95 per cent. He held that deep-seated and long-continued thrust pressure of the coal—the greatest alteration marking the greatest pressure—resulted in great improvement in the bituminous coals. His "Regional alteration of oil shales" (1915) stated that no petroleum in commercial quantities occurs where the coals have 75 per cent of pure carbon.

That same year brought his famous paper on "Some relations in origin between coal and petroleum," his great contribution to petroleum finding, the subject matter of which he presented as his presidential address before the Washington Academy of Sciences. In it he dwells on the parallelism between oil (and gas) in particular and coal carbonization. Very little attention was apparently paid to the address by the geologic profession, and the conclusions received practically no acceptance until Myron L. Fuller some years later directed attention to them. It was, in fact, nearly ten years before the economic importance of White's conclusions was fully perceived by the petroleum geologists, and the annual waste lessened by drilling only in areas in which the carbonization was not distinctly too advanced. Due to the theoretical aspects of the problem, the relation between the advancing grade of the oil and the advancing carbonization of a region was slow to be accepted by the oil geologists. It is nevertheless indubitably true, as White pointed out, that in regions where the mother rocks are but slightly carbonized, as shown by the very low fixed carbon content in pure coals, the oils are apt to be of low rank, whereas in every case where we have to do with pools associated with or underlying coal-bearing formations of high car-

bonization, we have high-rank oils, the highest rank of all being found nearest to the "oil dead line."

Twenty years after White published his epochal paper on the carbon ratio, he returned to the subject in "Metamorphism of organic sediments and derived oils" (1935) and responded to the criticisms which followed the original publication. The extinction zone, or "oil dead line," he says,

"is found in many regions to fall in a zone narrower than at first defined and represents a carbonization (indicated by fixed carbon, pure coal basis) between 61 and 63 of the associated coals" (p. 589).

WHITE'S STUDIES OF PRE-CAMBRIAN ALGAE

Work in connection with a committee of the National Academy of Sciences which sought to develop public interest in the scientific aspects of the national parks led White to become interested in the most primitive known plant fossils, the lime-secreting algae of the Proterozoic formations of the Grand Canyon and Glacier National Park. Had he lived to complete the task thus entered upon, the results would have formed one of his major contributions. From 1926 to 1930, he spent a month or more each year in the national parks, under the sponsorship of the Carnegie Institution of Washington, and, as stated before, it was the effects of the high altitude of these regions, and the carrying of heavy sacks of specimens up steep slopes, that had much to do with his breakdown in 1931. In consequence of this breakdown, White was unable to bring his studies to a conclusion, but much of value is at hand that will at least show, when published, why he regarded these fossils as actual organic growths and not of concretionary origin. It was for this work that he received the Walcott Medal of the National Academy of Sciences in 1934. He had intended to etch many polished surfaces of the algae, to take collodion pulls from them, and then to photograph the microstructure, but this plan had to be laid aside. He had made, however, a large number of very excellent photographs of the algal masses.

From 1927 on, he published nine short papers on the subject of these ancient algae, which give some of his preliminary results; besides these, the Carnegie Institution has two manu-

scripts, totaling thirty-six pages, which were written in 1931 and 1933. What follows is taken from the manuscript of 1933 and the abstract published that year. In both papers, White combats vigorously the view of Walcott that but little or no marine strata occur in the Proterozoic, and he cites many places in various continents where limestones several thousand feet thick, and great masses of black carbonaceous shales, are known. Accordingly, he insists that "the burden of proof that the known Pre-Cambrian is entirely of fresh-water origin rests with the geologists who still hold to that view."

White's manuscript of 1931 confirms Walcott's discoveries as to the "plenitude of Proterozoic algae," and states that many more are yet to be discovered. He is convinced that these most archaic of fossils "leave no room for doubt as to the organic origin of most of the forms brought to light." As yet, his studies do not permit him to give descriptive details of the forms, but much of the structure is "clearly discernable under proper manipulation," and much microstructure awaits further study. In typical *Collenia,* the layers

"are composed of radiate nearly parallel slender tubes which were deposited on the probably gelatinous sheath of the algal thallus. . . . These successive growths . . . resemble nothing in the present-day flora so closely as the layers of *Lyngbya* and *Inactis* deposits. . . . In fact, the agreement between the Arizona and the recent deposits is most striking."

The late Proterozoic, he concludes, is clearly the Age of Cyanophyta.

White's scientific spirit is truly indicated in the following lines from Whittier's poem, *The prayer of Agassiz:*

"We are searching here to find
What the hieroglyphics mean
Of the unseen in the seen,
What the thought which underlies
Nature's masking and disguise."

BIBLIOGRAPHY

OF

DAVID WHITE, 1862-1935

Compiled by Miss Olive C. Postley, U. S. Geological Survey

On the nature and systematic classification of *Ptilophyton vanuxemi*. Thesis for the degree of B.S. at Cornell University, 1886. Not published.

Carboniferous glaciation in the southern and eastern hemispheres—with some notes on the Glossopteris flora. Am. Geologist, vol. 3, pp. 299-330, 1889.

On Cretaceous plants from Martha's Vineyard. Am. Jour. Sci., vol. 39, no. 3, pp. 93-101, illus., 1890; abstract, with discussion by J. S. Newberry, L. F. Ward, and F. J. H. Merrill. Geol. Soc. America, Bull., vol. 1, pp. 554-556, 1890.

On the organization of the fossil plants of the Coal Measures. Bot. Gazette, vol. 15, pp. 172-175, June, 1891.

The Cretaceous at Gay Head, Martha's Vineyard, Mass. Science, vol. 20, pp. 332-333, 1892.

Flora of the outlying Carboniferous basins of southwestern Missouri. U. S. Geol. Survey, Bull. 98, 139 pp., illus., 1893.

A new taeniopteroid fern and its allies. Geol. Soc. America, Bull., vol. 4, pp. 119-132, illus., 1893.

The Pottsville series along New River, W. Va. Geol. Soc. America, Bull., vol. 6, pp. 305-320, 1895.

[Administrative Report, 1893-1894.] U. S. Geol. Survey, 15th Ann. Rept., pp. 180-182, 1895.

Report on the fossil plants from the Hindostan whetstone beds in Orange County, Ind. Indiana Dept. Geol. Nat. Res., Ann. Rept. 20, pp. 354-355, 1896.

The development of exogenous structure in the Paleozoic lycopods. Science, new ser., vol. 3, pp. 754-759, 1896.

The structure and relations of Buthograptus, Plumulina, and Ptilophyton from the North American Paleozoic. Science, new ser., vol. 3, p. 417, 1896.

Some new forms of Paleozoic algae from the central Appalachian region (abstract). Science, new ser., vol. 3, p. 331, 1896.

The thickness and equivalence of some basal Coal Measure sections along the eastern margin of the Appalachian basin (abstract). Science, new ser., vol. 3, pp. 534-535, 1896; Am. Geologist, vol. 17, p. 266, 1896.

Age of the lower coals of Henry County, Mo. Geol. Soc. America, Bull., vol. 8, pp. 287-304, 1897.

Omphalophloios, a new lepidodendroid type. Geol. Soc. America, Bull., vol. 9, pp. 329-342, illus., 1898; abstract, Science, new ser., vol. 7, p. 80, 1898.
(And Schuchert, C.) Cretaceous series of the west coast of Greenland. Geol. Soc. America, Bull., vol. 9, pp. 343-368, map, 1898; abstract, Science, new ser., vol. 7, pp. 52-53, 1898.
The probable age of the McAlester coal group (abstract). Science, new ser., vol. 7, p. 612, 1898.
Report on fossil plants from the McAlester coal field, Indian Territory, collected by Messrs. Taff and Richardson in 1897. U. S. Geol. Survey, 19th Ann. Rept., pt. 3, 1897-1898, pp. 457-534, pls. lxvii, lxviii, 1899.
Fossil flora of the lower Coal Measures of Missouri. U. S. Geol. Survey, Monograph 37, 467 pp., illus., 1899.
The stratigraphic succession of the fossil floras of the Pottsville formation in the southern anthracite coal field, Pennsylvania. U. S. Geol. Survey, 20th Ann. Rept., pt. 2, pp. 749-930, illus., 1900.
Relative ages of the Kanawha and Allegheny series as indicated by the fossil plants. Geol. Soc. America, Bull., vol. 11, pp. 145-178, 1900; abstract, Science, new ser., vol. 11, pp. 140-141, 1900.
Two new species of algae of the genus Buthotrephis, from the Upper Silurian of Indiana. U. S. Nat. Mus., Proc., vol. 24, pp. 265-270, illus., 1901.
Age of the coals at Tipton, Blair County, Pa. Geol. Soc. America, Bull., vol. 12, pp. 473-477, 1901.
Some palaeobotanical aspects of the Upper Palaeozoic in Nova Scotia. Canadian Rec. Science, vol. 8, pp. 271-280, 1901; abstract, Science, new ser., vol. 12, p. 885, 1900.
The Canadian species of the genus Whittleseya and their systematic relations. Ottawa Naturalist, vol. 15, pp. 98-110, illus., 1901.
Mr. Lacoe's relations to science. Wyoming Hist. Geol. Soc., Proc., vol. 6, pp. 55-60, 1901.
(And Campbell, M. R.) The bituminous coal field of Pennsylvania. U. S. Geol. Survey, 22d Ann. Rept., pt. 3, pp. 127-200, map, 1902.
The bituminous coal field of Maryland. U. S. Geol. Survey, 22d Ann. Rept., pt. 3, pp. 201-214, 1902.
Description of a fossil alga from the Chemung of New York, with remarks on the genus Haliserites Sternberg. New York State Mus., Bull. 52, pp. 593-605, illus., 1902.
Stratigraphy vs. paleontology in Nova Scotia. Science, new ser., vol. 16, pp. 232-235, 1902.
Summary of fossil plants recorded from the Upper Carboniferous and Permian formations of Kansas. U. S. Geol. Survey, Bull. 211, pp. 85-117, 1903.
Memoir of Ralph Dupuy Lacoe. Geol. Soc. America, Bull., vol. 13, pp. 509-515, 1903.

An anthracite coal field three and a half hours west of Washington, D. C. Science, new ser., vol. 17, p. 387, 1903.
Problematic fossils supposed to be seaweeds from the Hudson group (abstract). Science, new ser., vol. 17, p. 264, 1903.
Age of the Mercer group (abstract). Science, new ser., vol. 17, p. 942, 1903.
In Smith, E. A.: Carboniferous fossils in "Ocoee" slates in Alabama. Science, new ser., vol. 18, p. 246, Aug. 21, 1903.
(With Adams, G. I.) Stratigraphy and paleontology of the Upper Carboniferous rocks of the Kansas section. U. S. Geol. Survey, Bull. 211, 123 pp., maps, 1903.
Permian elements in the Dunkard flora (abstract). Geol. Soc. America, Bull., vol. 14, pp. 538-542, 1903; Jour. Geology, vol. 11, pp. 105-106, 1903; Science, new ser., vol. 17, p. 298, 1903.
Deposition of the Appalachian Pottsville. Geol. Soc. America, Bull., vol. 15, pp. 267-282, map, 1904; abstract, Science, new ser., vol. 19, pp. 24, 532, 1904.
A new seed-bearing fern (abstract). Science, new ser., vol. 20, p. 840, 1904.
The seeds of Aneimites. Smithsonian Misc. Coll., vol. 47 (Q. Is., vol. 2), pp. 322-331, illus., 1905.
In Stanton, T. W.: The time element in stratigraphy and correlation. Science, new ser., vol. 21, p. 585, 1905.
Fossil plants of the group Cycadofilices. Smithsonian Misc. Coll., vol. 47 (Q. Is., vol. 2), pp. 377-390, illus., 1905; abstract, Science, new ser., vol. 21, p. 664, 1905.
The occurrence of glacial epochs in Paleozoic time (abstract). Science, new ser., vol. 22, p. 335, 1905.
The age of the Wise and Harlan formations of southwestern Virginia (abstract). Science, new ser., vol. 22, pp. 335-336, 1905.
The American range of the Cycadofilices (abstract). 8th Int. Geog. Cong., Rept., p. 616, 1905.
(With Smith, G. O.) The geology of the Perry Basin in southeastern Maine. U. S. Geol. Survey, Prof. Paper 35, 107 pp., map, illus., 1905.
Geological position of the principal insect-bearing localities of the American Paleozoic. U. S. Nat. Mus., Proc., vol. 29, pp. 664-668, 1906.
(And Ashley, G. H.) Correlation of coals. U. S. Geol. Survey, Prof. Paper 49, pp. 206-212, 1906.
Report on fossil plants (from the Cape Lisburne region, Alaska). U. S. Geol. Survey, Bull. 278, p. 22, illus., 1906.
A source of hydrocarbons in the Ordovician (abstract). Science, new ser., vol. 23, pp. 814-816, 1906.
A remarkable fossil tree-trunk from the Middle Devonic of New York. New York State Mus., Bull. 107, pp. 327-360, illus., 1907.
Report on the field work in the coal districts of the State. Illinois Geol. Survey, Bull. 4, pp. 201-203, 1907.

Permo-Carboniferous climatic changes in South America. Jour. Geology, vol. 15, pp. 615-633, 1907; abstract, Geol. Soc. America, Bull., vol. 18, pp. 624-626, 1907.

Report on fossil plants from the Coal Measures of Arkansas. U. S. Geol. Survey, Bull. 326, pp. 24-31, 1907.

A composite lycopod type from the Devonian (abstract). Science, new ser., vol. 25, p. 269, 1907.

Report on field work done in 1907. Illinois Geol. Survey, Bull. 8, pp. 268-272, 1907.

Age of the plant beds in the K'ui-Chóu Basin. In Willis, Blackwelder, and Sargent, Carnegie Inst. Washington, Pub. 54, vol. 1, pt. 1, pp. 280-283, 1907.

Fossil flora of the Coal Measures of Brazil. (Commissão de Estudos das Minas de Carvão de Pedra do Brazil.) In I. C. White: Report on the Coal Measures and Associated Rocks of South Brazil. Rio de Janeiro, pt. 3, pp. 337-617, pls. v-xiv, 1908.

Some problems of the formation of coal. Econ. Geology, vol. 3, pp. 292-318, 1908; abstract, Science, new ser., vol. 25, pp. 965-966, 1907.

Correlation of Elkhorn coals (eastern Kentucky). U. S. Geol. Survey, Bull. 348, pp. 30-32, 1908.

Oxygen values and coal alteration (abstract). Science, new ser., vol. 27, p. 537, 1908.

The effect of oxygen in coal. U. S. Geol. Survey, Bull. 382, 74 pp., 1909.

The upper Paleozoic floras, their succession and range. Jour. Geology, vol. 17, pp. 320-341, 1909; reprinted in Willis, B., and Salisbury, R. D., Outlines of geologic history, pp. 139-160, Chicago, 1910.

Paleobotanical work in Illinois in 1908. Illinois Geol. Survey, Bull. 14, pp. 293-295, 1909.

Occurrence of resin in Paleozoic coals (abstract). Science, new ser., vol. 29, p. 945, 1909.

Graphic methods of representing the regional metamorphism of coals (abstract). Science, new ser., vol. 30, p. 62, 1909.

The regional devolatilization of coal (abstract). Science, new ser., vol. 32, p. 221, 1910; Geol. Soc. America, Bull., vol. 21, p. 788, 1910.

Permian floras in the western "Red Beds" (abstract). Science, new ser., vol. 32, p. 223, 1910.

(And Knowlton, F. H.) Evidences of paleobotany as to geological climate (abstract). Science, new ser., vol. 31, p. 760, 1910.

Value of floral evidence in marine strata as indicative of nearness of shores. Geol. Soc. America, Bull., vol. 22, pp. 221-227, 1911.

[Discussion of fossil plants.] In Gordon, C. H.: The Wichita formation of northern Texas. Jour. Geology, vol. 19, no. 2, pp. 130-131, 1911.

A Carboniferous flora [at St. John, N. B.] in the Silurian? Science, new ser., vol. 34, pp. 440-442, 1911.

The characters of the fossil plant Gigantopteris Schenk and its occurrence in North America. U. S. Nat. Mus., Proc., vol. 41, pp. 493-516, illus., 1912.

Age of the Worcester phyllite. Washington Acad. Sci., Jour., vol. 2, pp. 114-118, 1912.

(Formation of limestone near tide level) (abstract). Washington Acad. Sci., Jour., vol. 2, p. 357, 1912.

[Discussion of] Grabau, A. W.: Ancient delta deposits. Geol. Soc. America, Bull., vol. 23, p. 744, 1912.

Resins in Paleozoic coals (abstract). Science, new ser., vol. 35, p. 312, 1912; Geol. Soc. America, Bull., vol. 23, p. 728, 1912.

Excursion in eastern Quebec and the maritime provinces; the flora of the Gaspé sandstone; the Horton flora; note on the flora of the Coal Measures. 12th Int. Geol. Cong., Guide Book no. 1, pp. 108-110, 144-146, 250-251, Canada, 1913.

The fossil flora of West Virginia. West Virginia Geol. Survey, vol. 5 (A), pp. 390-453, 1913.

Roots in the underclays of coals (abstract). Geol. Soc. America, Bull., vol. 24, pp. 114-115, 719, 1913.

Pottsville-Allegheny boundary in the interior province (abstract). Geol. Soc. America, Bull., vol. 24, p. 716, 1913.

(And Thiessen, R.) The origin of coal. U. S. Bur. Mines, Bull. 38, 390 pp., 1913.

Resins in Paleozoic coals (abstract). 8th Int. Cong. Applied Chem., vol. 25, pp. 775-776, 1913.

A new fossil plant from the state of Bahia (Brazil). Am. Jour. Sci., 4th ser., vol. 35, pp. 633-636, 1913.

Resins in Paleozoic plants and in coals of high rank. U. S. Geol. Survey, Prof. Paper 85, pp. 65-83, 1914; abstract, Washington Acad. Sci., Jour., vol. 4, pp. 10, 225, 1914; Coll. Guard., vol. 108, pp. 309-310, 1914.

Notes of the fossil floras of the Pennsylvanian in Missouri. Missouri Bur. Geol. (2), vol. 13, pp. 256-262, 1915.

Some relations in origin between coal and petroleum. Washington Acad. Sci., Jour., vol. 5, pp. 189-212, map, 1915.

The occurrence of transported boulders in coal beds (abstract). Washington Acad. Sci., Jour., vol. 5, p. 407, 1915.

Regional alteration of oil shales (abstract). Geol. Soc. America, Bull., vol. 26, pp. 101-102, 1915.

(And others) Natural gas resources of parts of north Texas. U. S. Geol. Survey, Bull. 629, 126 pp., maps, 1916.

Charles Willard Hayes. Science, new ser., vol. 44, pp. 124-126, 1916.

Late theories regarding the origin of oil. Geol. Soc. America, Bull., vol. 28, pp. 727-734, 1917.

Organization and cost of geological surveys. 2d Pan American Sci. Cong., Proc., sec. 7, vol. 8, pp. 605-612, Washington, 1917.

Structure and oil and gas resources of the Osage Reservation, Okla. Introduction. U. S. Geol. Survey, Bull. 686, pp. v-xii, map, 1918.

[On the war work of the U. S. Geological Survey.] Am. Inst. Min. and Met. Eng., Trans., vol. 57, pp. xxix-xxxi, 1918.

[Discussion of] Winchester, D. E.: Contorted bituminous shales of Green River formation in northwestern Colorado. Washington Acad. Sci., Jour., vol. 9, p. 295, 1919.

The human resources of the Appalachian Mountains. Published by the Southern Industrial Educational Association, Inc., prior to 1920 [? 1919].

Oil—a waning heritage. Presented before the Society of the Sigma Xi at Cornell University, April 1920.

Genetic problems affecting search for new oil regions. Am. Inst. Min. and Met. Eng., Trans., vol. 65, pp. 176-198, 1921; Mining and Metallurgy, no. 158, sec. 1, p. 32 (abstract), sec. 21, 20 pp., February 1920; abstract, Eng. and Min. Jour., vol. 109, pp. 512-514, February 21, 1920; discussion by R. H. Johnson, H. W. Hixon, David Reger, and J. T. Duce, Am. Inst. Min. and Met. Eng., Trans. (preprint), no. 994, pp. 9-12, 1920.

The petroleum resources of the world. Am. Acad. Political and Social Science, Annals, vol. 89, no. 178, pp. 111-134, pls. (maps), May 1920.

Oil in South America. Published by Pan American Union, July 1921; Bol. Petrol., Mexico, vol. 12, pp. 28-37, 1921; vol. 13, pp. 310-315, 1922.

[Discussion of] Willis, B.: Geologic distillation of petroleum. Am. Inst. Min. and Met. Eng., Trans. (preprint), no. 1088, p. 20, August 1921.

[Discussion of] Williams, H. E.: Oil-shales and petroleum prospects in Brazil. Am. Inst. Min. and Met. Eng., Trans., vol. 65, p. 76, 1921.

[Discussion of] Semmes, D. R.: Oil possibilities in northern Alabama. Am. Inst. Min. and Met. Eng., Trans., vol. 65, p. 150, 1921.

[Discussion of] Johnson, R. H.: Water displacement in oil and gas sands. Am. Inst. Min. and Met. Eng., Trans., vol. 65, pp. 501, 504, 1921.

Oil shales of the United States. Am. Mining Cong., 23d Ann. Convention, Rept. of Proc., pp. 151-153, 1921.

Federal cooperation. Am. Mining Cong., 23d Ann. Convention, Rept. of Proc., pp. 456-470, 1921.

Our future oil supply. Eng. and Min. Jour., vol. iii, no. 21, pp. 951-955, June 4, 1921.

Potash reserves in west Texas. Mining and Metallurgy, no. 184, pp. 19-25, 2 figs., April 1922.

The unmined supply of petroleum in the United States. In Redwood, Boverton: Petroleum, 4th ed., vol. 1, pp. 92-96, 1 fig., London, 1922.

Oil reserves of the United States. Am. Inst. Min. and Met. Eng., Trans., vol. 68, pp. 953-958, 1923; (preprint) no. 1165, 6 pp., June 1922; abstract, Mining and Metallurgy, no. 186, pp. 37-38, June 1922.

The oil supply of the world. Mechanical Engineering, vol. 44, no. 9, pp. 567-569, September 1922; abstract, Eng. and Min. Jour., vol. 113, no. 11, pp. 455-456, March 18, 1922.

Problems in oil geology and their advancement through cooperative research. Am. Assoc. Petroleum Geologists, Bull., vol. 6, no. 6, pp. 509-515, November-December 1922.

[Discussion of] Longwell, C. R.: Geology of the Colorado River in southeastern Utah. Geol. Soc. America, Bull., vol. 33, p. 123, 1922.

Petroleum resources tributary to the Pacific Basin. Presented at Pan-Pacific Conference, Honolulu, October 1922; Oil Eng. and Finance, vol. 2, pp. 761-764, 791-793, 1922; Oil Eng., vol. 2, pp. 737-739, 1922.

Oil resources of the Japanese Empire. Memo. rept. for Military Intelligence Div., War Department.

(And Stadnichenko, T.) Some mother plants of petroleum in the Devonian black shales. Econ. Geology, vol. 18, no. 3, pp. 238-252, 5 pls., April-May 1923.

Radioactivity and oil-field location. Am. Assoc. Petroleum Geologists, Bull., vol. 7, no. 3, pp. 290-291, May-June 1923.

(And Morris, H. C.) Progress of the petroleum industry in 1922 in Europe, Asia, and Africa. February, 1923, meeting of Am. Inst. Min. and Met. Eng.

Causes of dryness in sedimentary strata. Presented before Soc. of Econ. Geol., 1923.

Geologic and technologic work of the Soviet Council of Petroleum Industry. Am. Assoc. Petroleum Geologists, Bull., vol. 7, no. 4, pp. 447-453, July-August 1923.

Some needed peat investigations. Am. Peat Soc., Jour., vol. 17, no. 2, pp. 45-56, April 1924.

Gravity observations from the standpoint of the local geology. Presidential address, Geol. Soc. America, Bull., vol. 35, no. 2, pp. 207-277, 1 pl., June 30, 1924.

Researches in geology of finding and recovery of oil. Nat. Petroleum News, vol. 16, no. 43, pp. 85, 87, October 22, 1924.

Proposed oceanographic research by the Navy. Jour. Geology, vol. 32, no. 8, pp. 690-695, November-December 1924.

Permian of western America from the paleobotanical standpoint. Pan-Pacific Sci. Cong., Australia, 1923, Proc., vol. 2, pp. 1050-1077 [1924].

Researches in geology of finding oil. Oil and Gas Jour., vol. 23, no. 20-A, pp. 64-A, 196-H, October 9, 1924; Petrol. World, vol. 21, pp. 515-519, 1924.

Prehistoric forests of Pennsylvania. Published in "Forest Leaves" (Phila.), vol. 19, no. 11, October 1924.

Quelques relations entre les charbons de différentes espèces et la composition des dépôts sédimentaires originels. Soc. géol. Belgique, Livre jubilaire, 1874-1924, t. 1, pp. 365-378, 1 pl., 1924.

(And Stadnichenko, T.) Some mother plants of petroleum in the Devonian black shales. Kentucky Geol. Survey, ser. 6, vol. 21, pp. 99-117, 5 pls., 1925.

Plant fossils [indications of ancient climate] (abstract). Science, new ser., vol. 61, p. xii, January 9, 1925.

Environmental conditions of deposition of coal. Am. Inst. Min. and Met. Eng., Trans. (preprint), no. 1402, 21 pp., January 1925; (with discussion), Trans., vol. 71, pp. 253-281, 3 figs., 1925; abstract, Min. and Met., vol. 6, no. 222, pp. 300-301, June 1925; Min. Jour., vol. 149, pp. 441-442, 461-462, 478, 502, 1925.

[Discussion of] Jeffrey, E. C.: Coal in relation to coke. Am. Inst. Min. and Met. Eng., Trans., vol. 71, pp. 158-160, 1925.

[Discussion of] Fieldner, A. C., and Davis, J. D.: Modern views of the chemistry of coals of different ranks as conglomerates. Am. Inst. Min. and Met. Eng., Trans., vol. 71, pp. 243-244, 1925.

[Discussion of] Francis, W., and Wheeler, R. V.: Resolution of coal by oxidation. Am. Inst. Min. and Met. Eng. Trans., vol. 71, p. 175, 1925.

Some problems of the conservation of American mineral resources. Lecture at Army War College, Washington Barracks, Dec. 7, 1925 (Mim. copy no. 160), ASW Course no. 7.

Progressive regional carbonization of coals. Am. Inst. Min. and Met. Eng., Trans. (preprint), no. 1414, 27 pp., February 1925; (with discussion), Trans., vol. 71, pp. 253-281, 3 figs., 1925; abstract, Min. and Met., vol. 6, no. 222, pp. 300-301, June 1925.

Projected oceanographic investigations (abstract). Geol. Soc. America, Bull., vol. 36, no. 1, p. 147, March 30, 1925; Pan-Am. Geologist, vol. 43, no. 2, pp. 146-147, March 1925.

Upper Paleozoic climate as indicated by fossil plants. Sci. Monthly, vol. 20, no. 5, pp. 465-473, May 1925.

Coal. Sci. Monthly, vol. 21, no. 2, pp. 177-181, August 1925.

Late Paleozoic climates as indicated by fossil plants (abstract). Pan-Am. Geologist, vol. 44, no. 1, p. 73, August 1925.

Public geology and national mineral wealth. International Geol. Cong., 13th Sess., Belgium, 1922, Compt. Rend., fasc. 3, pp. 1711-1718, 1926.

General features of the Mississippian floras of the Appalachian trough. West Virginia Geol. Survey, Mercer, Monroe, and Summers counties, pp. 837-843, 1926.

Geologic factors affecting and possibly controlling Pleistocene ice sheet development in North America (abstract). Washington Acad. Sci., Jour., vol. 16, no. 3, pp. 69-72, February 4, 1926.

Some cold waves of geologic history. Sci. Monthly, vol. 22, no. 4, pp. 359-363, April 1926.

Paleontological exploration of caves. Mimeographed. Nat. Research Council, June 1, 1926.

(And Stadnichenko, T.) Microthermal observations of some oil shales and other carbonaceous rocks (abstract). Oil and Gas Jour., vol. 24,

no. 46, p. 20, April 1926; Am. Assoc. Petroleum Geologists, Bull., vol. 10, no. 9, pp. 860-876, September 1926.
Possibility of oil structures out in Gulf of Mexico. Oil and Gas Jour., March 10, 1927.
Memorial of Frank Hall Knowlton. Geol. Soc. America, Bull., vol. 38, no. 1, pp. 52-70, portr., March 30, 1927.
The flora of the Hermit shale in the Grand Canyon, Arizona. Nat. Acad. Sci., Proc., vol. 13, no. 8, pp. 574-575, August 1927.
Study of the fossil floras in the Grand Canyon, Arizona. Carnegie Inst. Washington, Year Book no. 26, pp. 366-369, December 1927.
Questions back of the Mississippi flood problems. Am. Shore and Beach Preservation Assoc., Rept., meeting of May 23-24, 1927.
Discussion of floating continents. In Theory of continental drift, pp. 187-188, Am. Assoc. Petroleum Geologists, 1928.
Some factors in rock metamorphism. Nat. Acad. Sci., Proc., vol. 14, no. 1, pp. 5-7, January 1928.
Some factors for consideration in an appraisal of the oil possibilities of the United States, with map classifying the different parts of the United States with reference to their oil possibilities. Presented before 2d International Conference on Bituminous Coal, 1928. Not published.
A spiral graph of geologic time. Washington Acad Sci., Jour., vol. 18, no. 8, pp. 201-203, 1 fig., April 19, 1928.
The promotion of knowledge of pre-Cambrian life. Science, new ser., vol. 67, pp. 620-621, June 22, 1928.
Algal deposits of Unkar Proterozoic age in the Grand Canyon, Arizona. Nat. Acad. Sci., Proc., vol. 14, no. 7, pp. 597-600, July 1928.
Encouragement of pre-Cambrian paleontology. Jour. Geology, vol. 36, no. 8, pp. 743-744, November-December 1928.
Study of the fossil floras in the Grand Canyon, Arizona. Carnegie Inst. Washington, Year Book no. 27, 1927-28, pp. 389-390, 1928.
Need for research in the mineral resources of West Virginia. Speech delivered on occasion of inauguration of Pres. Turner of Univ. of W. Va., November 28, 1928. Published by Univ. of W. Va.
[Discussion of] Finch, J. W.: Sedimentary metalliferous deposits of the Red Beds. Am. Inst. Min. and Met. Eng., Trans., vol. 76, pp. 385-386, 1928.
Study of the fossil floras in the Grand Canyon, Ariz. Carnegie Inst. Washington, Year Book no. 28, pp. 392-393, 1929.
Interpreting the Grand Canyon. Science, new ser., vol. 69, pp. 671-672, June 28, 1929.
Description of fossil plants found in some "mother rocks" of petroleum from northern Alaska. Am. Assoc. Petroleum Geologists, Bull., vol. 13, no. 7, pp. 841-848, 8 pls., July 1929.
Flora of the Hermit shale, Grand Canyon, Ariz. Carnegie Inst. Washington, Pub. no. 405, 221 pp., 55 pls., December 1929.

History through a thousand million years: Extraordinary records of geological time and fossil life found in National Parks of northern Arizona and southern Utah. Published by Science Service in 1929.

Study of the fossil floras in the Grand Canyon, Ariz. Carnegie Inst. Washington, Year Book no. 29, pp. 400-403, 1930.

Deposition and age of the Hermit shale (abstract). Pan-Am. Geologist, vol. 53, no. 1, pp. 72-73, February 1930; Geol. Soc. America, Bull., vol. 41, no. 1, p. 47, March 31, 1930.

Obituary; Hilbert A. C. Jenison. Washington Acad. Sci., Jour., vol. 20, no. 10, pp. 190-191, May 19, 1930.

Iron bacteria in silicified bog-iron deposits of Cambro-Ordovician age (abstract). Science, new ser., vol. 71, p. 544, May 23, 1930.

Exchange of time for temperature in petroleum generation. Am. Assoc. Petroleum Geologists, Bull., vol. 14, no. 9, pp. 1227-1228, September 1930.

Outline of a suggested classification of coals. Am. Inst. Min. and Met. Eng., Trans., Coal Div., pp. 517-528, 1930.

[Discussion of] Turner, H. G.: Constitution and nature of Pennsylvania anthracite. Am. Inst. Min. and Met. Eng., Trans., Coal Div., pp. 642-643, 1930.

[Discussion of] Thiessen, R.: Splint coal. Am. Inst. Min. and Met. Eng., Trans., Coal Div., pp. 671-672, 1930.

Study of the fossil floras in the Grand Canyon, Arizona. Carnegie Inst. Washington, Year Book no. 30, p. 451, 1931.

Climatic implications of Pennsylvanian flora. Illinois State Geol. Survey, Bull. no. 60, pp. 271-281, 1931.

Age of the Maroon and Weber in central Colorado (abstract). Geol. Soc. America, Bull., vol. 42, no. 1, pp. 180-181, March 31, 1931; Pan-Am. Geologist, vol. 55, no. 1, p. 60, February 1931.

The carbonaceous sediments. In Twenhofel, W. H., *et al.:* Treatise on sedimentation. 1st edit., pp. 266-316, 1926; 2d edit., pp. 351-430, 1932.

Henry Marc Ami. Geol. Soc. America, Bull., vol. 43, no. 1, pp. 23-43, portr., March 1932.

Megalopteris and the giant winged cardiocarps (abstract). Geol. Soc. America, Bull., vol. 44, pt. 1, p. 213, February 28, 1933.

Some features of flowers and fruit of a new Cordaites (abstract). Science, new ser., vol. 77, p. 460, May 12, 1933.

Role of water conditions in the formation and differentiation of common (banded) coals. Econ. Geology, vol. 28, no. 6, pp. 556-570, September-October 1933.

Pre-Cambrian seas (abstract). Washington Acad. Sci., Jour., vol. 23, no. 12, pp. 570-571, December 15, 1933.

Presentation to H. L. Fairchild. Geol. Soc. America, Bull., vol. 44, pp. 50-52, 1933.

Some erroneous age records of Paleozoic plant genera. Science, new ser., vol. 79, no. 2039, pp. 77-78, January 26, 1934.

The age of the Pocono. Am. Jour. Sci., 5th ser., vol. 27, no. 160, pp. 265-272, April 1934.

Pocono age, orogeny, and climate. Geol. Soc. America, Proc., 1933, p. 119, June 1934.

The seeds of *Supaia,* a Permian pteridosperm (abstract). Science, new ser., vol. 29, no. 2055, p. 462, May 18, 1934.

Report for Committee on Paleobotany. Nat. Research Council, June 1934.

Age of Jackfork and Stanley formations of Ouachita geosyncline, Arkansas and Oklahoma, as indicated by plants. Am. Assoc. Petroleum Geologists, Bull., vol. 18, no. 8, pp. 1010-1017, August 1934.

Schuchert presentation address before National Academy of Sciences. Science, new ser., vol. 80, pp. 537-538, December 14, 1934.

Outstanding features of petroleum development in America. Am. Assoc. Petroleum Geologists, Bull., vol. 19, pp. 469-502, April 1935. (Sections 1 to 6 of History and origin of oil: Pt. 2 of the Hearings before a Subcommittee of the Committee on Interstate and Foreign Commerce, House of Representatives, 73d Congress (Recess), on H. Res. 441, 1934.)

Effects of geophysical factors on the evolution of oil and coal. (Read before meeting of Institution of Petroleum Technologists, London, 1934, in connection with Boverton Redwood medal.) Inst. Petroleum Technologists, Jour., vol. 21, no. 138, pp. 301-310, April 1935.

Metamorphism of organic sediments and derived oils. Am. Assoc. Petroleum Geologists, Bull., vol. 19, no. 5, pp. 589-617, May 1935.

Some features of the American Permian. Presented at the sessions of the 16th International Geological Congress, Washington, July 1933; reprints published in 1934; abstract, Pan-Amer. Geol., vol. 60, no. 4, pp. 314-315, November 1933.

Fossil plants from the Stanley shale and Jackfork sandstone in southeastern Oklahoma and western Arkansas. (To be published by the U. S. Geol. Survey.)

Fossil flora of the Wedington sandstone member of the Fayetteville shale. (To be published by the U. S. Geol. Survey.)

Fossil floras of the Pottsville formation of the Eastern Interior Basin. (Probably to be published by the Illinois Geol. Survey; 75 per cent complete.)

Reviews

The coals of South Wales, with special reference to the origin and distribution of anthracite, by Aubrey Strahan and W. Pollard, assisted by E. G. Radley. Econ. Geology, vol. 4, p. 274, 1909.

The Paleozoic coalfields of Holland. The deeper geology of the Netherlands and adjacent regions, with special reference to the latest borings in the Netherlands, Belgium and Westphalia, by W. A. J. M. Van Waterschoot Van Der Gracht, with contributions on the fossil flora by W. Jongmans. Econ. Geology, vol. 5, p. 391, 1910.

The formation of coal beds, by J. J. Stevenson. Econ. Geology, vol. 7, p. 89, 1912.

The sedimentary deposition of oil, by Murray Stuart. Econ. Geology, vol. 7, p. 91, 1912.

Anleitung zur Bestimmung der Karbonpflanzen West Europas. Bd. I, by W. J. Jongmans. Bot. Gazette, vol. 53, pp. 252-253, 1912.

Cannel coals, lignite and mineral oil in Scotland, by W. Gibson. Econ. Geology, vol. 18, p. 414, 1923.

Das Erdöl und seine Verwandten, by H. Höfer-Heimhalt. Econ. Geology, vol. 19, p. 96, 1924.

Biographical Sketches of David White

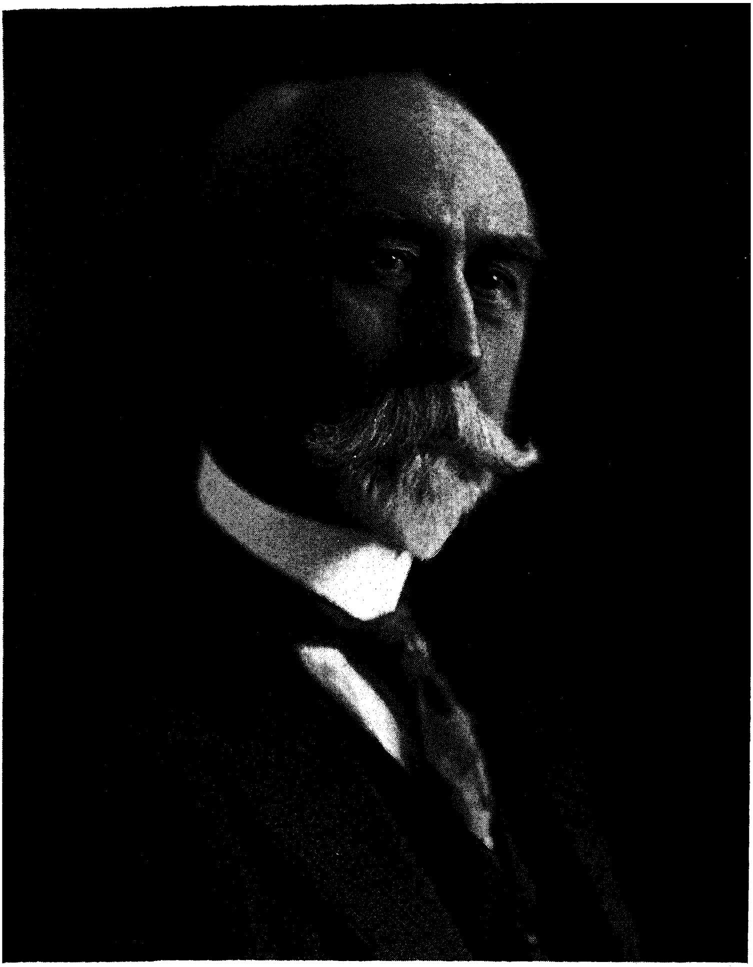
David White, by W. C. Mendenhall. Science, new ser., vol. 81, pp. 244-246, March 8, 1935.

David White, by E. W. Berry. Am. Jour. Sci., 5th ser., vol. 29, pp. 390-391, April, 1935.

David White, by Hugh D. Miser. Am. Assoc. Petroleum Geologists, Bull., vol. 19, pp. 925-931, June 1935.

Appreciation of Doctor David White, by the Oklahoma City Geological Society. Am. Assoc. Petroleum Geologists, Bull., vol. 19, pp. 931-932, June 1935.

David White Memorial at Ada, Oklahoma. Remarks by Hugh D. Miser, E. W. Berry, and others. Am. Assoc. Petroleum Geologists, Bull., vol. 20, pp. 624-632, 1936.



W. H. Holmes.

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVII—TENTH MEMOIR

BIOGRAPHICAL MEMOIR

OF

WILLIAM HENRY HOLMES

1846–1933

BY

JOHN R. SWANTON

PRESENTED TO THE ACADEMY AT THE AUTUMN MEETING, 1935

WILLIAM HENRY HOLMES
1846–1933

BY JOHN R. SWANTON

I

Alliance of the scientific and artistic abilities in eminent men is by no means rare but in comparatively few cases have they been so evenly developed or furnished such consistent support to each other as in the case of Dr. Holmes. Although he occupied scientific positions and was engaged in scientific work during the greater part of his life, his earliest instincts tended rather toward the graphic arts, he first attracted attention because of his gifts in that direction, received his premier appointment as an artist, and terminated his public career as director of a gallery devoted to the arts.

The farm near Cadiz, Harrison County, Ohio, on which Holmes's parents, Joseph and Mary Heberling Holmes, lived at the time of his birth was a subdivision of the original grant to his grandfather made in 1800, and he represented the eighth generation of the Holmes family in America. He was fond of recalling the fact that his birthday, December 1, 1846, fell in the same year as that of the Smithsonian Institution with which so much of his later life was to be identified.

His mother having died when he was ten, Holmes lived for a year with his grandparents at Georgetown, two and a half miles away. From the country schools he passed in 1865 into the McNeely Normal School at Hopedale, graduated in 1870, and from that institution in 1889 he received the honorary degree of A.B. During his undergraduate period he taught in the country schools at Red Hill, Science Hill, and Beech Spring, and he suspended his normal school work during most of the winter of 1866-67 when he made two unsuccessful endeavors to follow his artistic leanings by obtaining instruction from artists in Steubenville and Cleveland. Mr. E. F. Andrews of Steubenville, to whom he first applied, was later Principal of the Corcoran School of Art at Washington while Holmes was Curator of the

National Gallery of Art, and when Andrews died in October, 1917, and a tablet was dedicated to his memory in the Corcoran Gallery, Dr. Holmes was present and delivered an address in his honor. His second quest for education in art was made during the spring of 1867 when he spent one term at the Willoughby Collegiate Institute in Cleveland, the artist of whom he sought instruction being Miss Caroline Ransome.

In 1870-71 Holmes was teacher of geography, natural history, drawing, and painting at the McNeely Normal School, but, concluding that if he were going to continue teaching he must secure a more thorough training, he made arrangements to enter the State Normal School at Salem, Massachusetts. In April, 1871, however, before this plan could be carried out, he obtained an introduction to Theodore Kauffman, a painter of much local repute in the national capital, and soon afterward proceeded to Washington to enter his school.

It happened that Mary Henry, daughter of the first Secretary of the Smithsonian Institution, was also a pupil of Kauffman and through her Holmes soon learned of the existence of that Institution and proceeded to acquaint himself with it. On his very first visit, however, while sketching a brightly colored bird exhibited in one of the showcases, he attracted the attention of a young Costa Rican naturalist, Dr. José Zeledon, who, recognizing his ability, introduced him in turn to the scientists of the Institution and he was soon engaged by Dr. F. B. Meek, the paleontologist, to draw fossil shells, and by the eminent naturalist Dr. W. H. Dall to sketch shells of living species of mollusks.

This experience led, in May, 1872, to an appointment as artist to the U. S. Geological Survey of the Territories under Dr. F. V. Hayden, and he accompanied the party to the Yellowstone region, made into a park that same year, where he had ample opportunity to demonstrate his skill with the pencil and also to build up considerable reputation for himself as a mountain climber. He bestowed its name upon Great Fountain Geyser, the principal geyser of the Lower Geyser Basin of the Yellowstone.

The following winter was spent in preparing maps and illustrations for the Survey, and in the summer of 1873 he was with a party engaged in mapping out the Territory of Colorado from

Denver as a base. His reputation as artist and as mountain climber was much enhanced during this expedition, and he made what is supposed to have been the first ascent of the Mountain of the Holy Cross.

Holmes had now so far mastered field geology as to be appointed an Assistant Geologist the year following when he aided the Director in his studies of the mountain masses of central Colorado, and in the summer of 1875 he was given personal charge of a party assigned to the survey of the San Juan valley in New Mexico and Arizona. Reports on this work consumed most of the following winter and later he was occupied with the preparation of exhibits for the Centennial Exhibition at Philadelphia. Next summer he was, with A. D. Wilson, engaged on the primary triangulation of the great mountain systems of Colorado, and incidentally he climbed a dozen or more peaks of about 14,000 feet elevation, including all the more famous ones. He notes that he made the ascent of about thirty mountains altogether, and he gave names to seven.

Throughout 1877 Holmes was in Washington preparing reports, maps, and illustrations for the Survey, but he was again in the field during the season of 1878 when he followed the Wind River Mountains and Snake River up into Yellowstone Park. On the way a short stop was made to observe the total eclipse of July 29, Holmes executing some drawings of the corona in color.

Because of an important contribution made by him to the laccolitic concept of mountain building, Prof. Gilbert bestowed his name in 1877 upon a peak in the Henry Mountains, and in 1878 Henry Gannett, chief topographer to the Survey, with the approval of Director Hayden, gave the name Mt. Holmes to another in the Gallatin Range of Yellowstone Park in recognition of the part Holmes had played in the work of that year. Dr. C. A. White, the paleontologist, named a fossil shell *Unio holmesianus,* and at a later date a striking elevation along the Colorado Canyon was called Holmes Tower by George Wharton James.

In June, 1879, Holmes interrupted his geological work to visit Europe where he spent the remainder of that year and half of the year following. He examined collections in the noted museums and galleries, and before his return made sketching

trips to Rome, Venice, Naples, and other Italian cities, but during most of the winter worked in Munich in the American art colony of which Frank Duveneck was the leading spirit.

The Hayden Survey having been discontinued by Congress at the end of 1879 to make way for the new U. S. Geological Survey under Clarence King, Holmes, immediately after his return from Europe, was given the task of closing up the affairs of the former and this took much of his time during 1880 and 1881. January 1, 1881, he was appointed a temporary Assistant Geologist in the new Survey and this was made permanent two months later. He was now directed to join Major Clarence E. Dutton, Geologist, in surveying the Grand Canyon of the Colorado, and his panoramic views of this natural wonder, the principal from Point Sublime, are often cited as classic examples of the highest possibilities in applying the graphic art to geology. The following year he drew these panoramas in pen line and in color for reproduction in the atlas of Colorado, and prepared the maps for this great volume.

July 1, 1883, Holmes's title was changed to that of Geologist, and he continued in that capacity until June 30, 1889, when he resigned from the Survey to accept appointment as Archeologist in the Bureau of American Ethnology.

II

This last movement was, however, merely the culmination of interests which had been set in motion as far back as 1875 during Holmes's visit to the valley of the San Juan, a country covered with remains of the so-called "Cliff Dwellers," remains which he examined with interest and took care to report upon along with his discussions of the strictly geological features. He made some incidental observations on Indian remains in North Carolina in 1877. In 1878, on his second visit to the Yellowstone, he studied and reported upon the aboriginal obsidian quarries there and the Indian implements found about them. On the establishment of the Bureau of American Ethnology in 1879 he was given supervision of all the illustrations entering into its publications and soon began studying the archeological collections in the National Museum, particularly the objects of shell and pottery. In 1882 this interest was recognized and facilitated

by an honorary appointment in the Museum as Curator of Aboriginal Pottery.

In October, 1883, Holmes married Miss Kate Clifton Osgood and soon afterward built a home at 1454 Belmont St., Washington, which he continued to occupy, with one brief interruption, until the death of his wife in 1925 when he transferred his living quarters to the Cosmos Club and remained there as long as he continued in the Capital City. Two sons, Osgood Holmes and William Heberling Holmes, were born of this marriage and with the latter, at Royal Oak, Michigan, he passed the last months of his life.

In the spring of 1884 he spent two months in Mexico traveling in a special car as the guest of Mr. and Mrs. Chain, professional photographers, the noted photographer, W. H. Jackson, being also a guest. This gave Holmes a new opportunity to study "peoples, museums, ancient ruins and a number of the great volcanic mountains," but his first strictly anthropological field experience came in August, 1887, when he was asked to join a party of scientists planning three months' field work to be mainly devoted to the Indian tribes and ancient ruins of New Mexico and Arizona. Besides Secretary Langley of the Smithsonian Institution, this party included Major J. W. Powell, Director of the Geological Survey and of the Bureau of American Ethnology; James Stevenson, Assistant to Dr. Hayden, and Matilda Coxe Stevenson. Holmes's participation in this scientific enterprise was cut short, however, about the end of September, in a most painful manner by severe injuries brought on in the long and laborious descent of Jemez Mountain, so that it was necessary to take him to the nearest railroad station and send him back to Washington. In a few weeks he had recovered but he afterwards found it necessary to avoid any severe strain affecting the spine.

In the meantime, Holmes's experience acquired in connection with the Centennial Exhibition of 1876 had been enlisted in the preparation of exhibits for the expositions at New Orleans (1883-4) and Louisville (1884), and he performed a similar service for the Centennial Exposition of the Ohio Valley at Cincinnati in 1888.

After his appointment to the Bureau of American Ethnology in 1889 to take charge of its archeologic field work, Holmes made an exhaustive study of the Indian quarries on Piney Branch Creek and the west side of Rock Creek in the District of Columbia and later extended his survey to include the entire valley of the Potomac and the region west of it as far as the Alleghany, as also the tidewater sections of Maryland and Virginia. Incidental trips were made to mound groups in Wisconsin, Arkansas, Georgia, Mississippi, and Ohio, the novaculite quarries at the Hot Springs of Arkansas, quarries at Flint Ridge, Ohio, and in the northeastern part of the present Oklahoma, and the red pipestone quarries of Minnesota, besides the aboriginal copper mines on Isle Royale, Lake Michigan. In 1892-93 he examined the site of the famous Trenton finds in the Delaware Valley.

Much of this work was motivated by a heated discussion among the archeologists of the period as to the occurrence of paleolithic implements in America similar to those in the Old World. Numbers of crudely flaked stones had been collected and gathered into museums under the name of "paleoliths" and finds of such implements in situ were reported from various places in North America, particularly the Delaware Valley, where it was claimed that human artifacts had been found under glacial gravels, while remains indicating a far greater antiquity were reported from California. Noting the striking resemblance of most of these so-called "paleoliths" to rejected material he had observed about Indian workshops, Holmes took a pronounced stand against the validity of the paleolithic theory as applied to America, and, so far as the bulk of this material was concerned, his views were soon triumphantly substantiated, the protagonists of any but a very moderate antiquity for man in America being placed wholly on the defensive, though it should be added that Holmes himself perhaps inclined somewhat too far in the opposite direction.

While this controversy was going on, Holmes also devoted a large share of his time to the preparation of monographs on the textiles, the lithic and the ceramic arts of the American Indians, works which brought him his first general recognition among anthropologists. For his report on "Stone Implements of the Potomac-Chesapeake Tidewater Province" he was awarded the

First Loubat Prize amounting to $1000, as the best work on "the history, geography, archaeology, philology, or numismatics of North America" to appear during the five year period 1894-98. About thirty years later, in 1923, he was awarded the Second Loubat Prize for his "Handbook of Aboriginal American Antiquities."

In 1892, owing largely to the influence of his friend, the famous geologist T. C. Chamberlin, Holmes was appointed non-resident Professor of Anthropic Geology in the University of Chicago, the year following he spent largely in Chicago superintending the installation of Smithsonian exhibits at the World's Columbian Exposition, and in 1894 he was induced to resign from the Bureau of American Ethnology to accept the Curatorship of Anthropology in the newly established Field Columbian Museum. On May 16 a farewell banquet was tendered him by his friends and associates in Washington at which he was presented with a silver loving cup bearing an appropriate inscription.

During the winter of 1894-95 Holmes enjoyed an unusual treat in the opportunity afforded him to visit Yucatan and the neighboring parts of Mexico as the guest of Mr. Allison Armour on the latter's yacht, the Ituna, and the sketches made by him at this time served to render his "Archeological Studies among the Ancient Cities of Mexico" (printed in 1895) a publication of unique interest and importance.

In 1896 Holmes was for a brief period acting director of the Field Museum, but the Chicago situation not having developed in an entirely satisfactory manner, the year following he yielded to the earnest solicitations of Dr. Charles D. Walcott, then Assistant Secretary of the Smithsonian Institution, and returned to Washington to fill the position of Head Curator of the Department of Anthropology in the U. S. National Museum. One passage in the letter in which he intimates his willingness to return is worthy of perpetuation along with other memories of him. He says:

"Considering all phases of the case, however, I am ready to say that if an opening should develop for me in Washington. . . . I should be deeply gratified, but I beg that you will not feel for a moment that you must provide for me and especially I would

stipulate that, whatever is done, other worthy people should not suffer on account of my ambitions."

In 1898 he was in charge of the Smithsonian exhibits at the Trans-Mississippi and International Exposition at Omaha, and during the last three months of that year, in company with W J McGee, he visited the soapstone quarries on Catalina Island, California, besides investigating the circumstances under which the famous Calaveras skull had made its appearance, which he quickly and justly suspected of involving an imposture or at least a serious error. A small ethnological collection was made also from the Pomo, Tulare and other Indians. In 1899, in company with Dutton, Gilbert, and W. W. Blake, a friend residing in Mexico, he made a tour of that republic as the guest of Mr. George W. Breckenridge, a banker of San Antonio, Texas, in the course of which he visited the obsidian quarries near Pachuca in the State of Hidalgo. In February and March of 1900 he accompanied Major Powell to Cuba and Jamaica in an attempt to obtain data regarding possible lines of migration between the southern and northern continents, and when they were joined by Secretary Langley, he used his talents to assist the latter in his study of the flight of the turkey buzzard, "the object being to learn something of the secrets of flight and their possible application to the development of the flying machine." A third visit to Mexico followed involving further studies of both a scientific and an artistic nature.

In 1901 Holmes visited an aboriginal flint quarry in Union County, Illinois, in company with Dr. W. A. Phillips of the Field Columbian Museum, and afterwards went to the northeastern part of Indian Territory, the present Oklahoma, with De Lancey Gill, illustrator for the Bureau of American Ethnology, to examine the contents of a spring which had been used as a shrine by the aborigines, and to the salt spring region near Kimmswick, Missouri. This last was revisited in company with Mr. Gerard Fowke the year following, 1902, and considerable prehistoric Indian material obtained. Subsequently he investigated the locale of the skeleton known as the Lansing Man. The same year he had charge of Smithsonian exhibits at the Pan-American Exposition at Buffalo, and the South Carolina Interstate and West Indian Exposition at Charleston.

On October 11, 1902, Holmes was appointed to the headship of the Bureau of American Ethnology made vacant by the death of Major J. W. Powell, its founder, on September 23 preceding, but he did so with the stipulation that his designation should be merely that of Chief instead of Director, and that he should serve at a reduced salary. His connection with the Museum was preserved, through the bestowal upon him of the honorary title of Curator of Prehistoric Archeology in that institution. The following year he visited quarry sites at Leslie, Missouri, and in Georgia and Alabama, and he was at the same time instrumental in establishing a Division of Physical Anthropology in the Museum with Dr. Aleš Hrdlička at its head. In 1904 he attended and took part in the Fourteenth International Congress of Americanists at Stuttgart, Germany, as representative of the United States Government, the Smithsonian Institution, the National Geographic Society and other bodies, expending considerable time also in visiting various museums and studying certain of their features for subsequent use in designing the new building of the National Museum now known as the Natural History Building. The anthropological exhibits of the National Museum and the Bureau of American Ethnology at the Louisiana Purchase Exposition, St. Louis, 1904, were prepared under his direction as were those at the Jamestown Tri-Centennial Exposition at Hampton Roads, Va., in 1907.

When Theodore Roosevelt was inaugurated President of the United States in 1905, Holmes was a member of the committee in charge of the inaugural ceremony, and eight years later, at the inaugural of Wilson, he was appointed a member of the Committee on Reception by its chairman, Thomas Nelson Page. He was elected president of the Cosmos Club, of which he had been a founder, for the year 1907-8, and he was a delegate of the Smithsonian Institution and The George Washington University to the Pan-American Scientific Congress at Santiago, Chile, December 1908 to January 1909. Later he assisted in setting up the exhibits for the Yukon-Pacific Exposition at Seattle and en route stopped at the Grand Canyon to select a suitable site for the memorial to Major J. W. Powell, which he determined should be at Sentinel Point.

An outstanding event during Dr. Holmes's incumbency as Chief of the Bureau of American Ethnology was the appearance of the Handbook of American Indians North of Mexico under the editorship of Mr. F. W. Hodge.

In 1909 Holmes resigned his position in the Bureau to devote his entire attention to the collections of the National Museum which interested him more personally, and on January 1, 1910, he resumed his status as Head Curator of Anthropology in that institution. He regarded the installation and classification of the Museum's archeological material as his most important work during the period that followed, and the groups illustrating aboriginal Indian life which he then designed certainly deserve special recognition, but of even more permanent value probably was the completion and publication of Part I of a Handbook of Aboriginal American Antiquities, treating of the lithic industries, a work which he had begun while Chief of the Bureau of American Ethnology. It must be considered a major misfortune that Part II of this work was never finished.

In March and April, 1916, Holmes visited the great ruined cities of Guatemala and Honduras in company with Dr. Sylvanus G. Morley of the Carnegie Institution, an expedition destined to be his last, and the same year he assisted in classifying the collections in the Detroit Museum. His seventieth birthday, also occurring in 1916, was made the occasion for a dinner in his honor given by his friends and associates at which he was presented with a volume of anthropological papers brought together and edited by Mr. F. W. Hodge, his successor as head of the Bureau of American Ethnology. On July 5, 1918, the degree of Doctor of Science was conferred upon him by The George Washington University in recognition of his distinguished abilities and attainments.

Dr. Holmes was a fellow the American Association for the Advancement of Science, a member and founder of the American Anthropological Association, a member of the Anthropological Society of Washington, the Philosophical Society of Washington, the American Folk-Lore Society, and the Archaeological Institute of America, and Chairman of the Managing Committee of the School of American Archaeology.

III

Still another change of interest and activity in the life of Dr. Holmes had been prefigured as far back as August 10, 1906, when he was appointed temporary Curator of the National Gallery of Art. This appointment was made permanent January 1, 1910. From a valuation of a few thousand dollars which the art collections possessed in 1906, they had grown in size and importance by 1920 to an estimated value of ten million, and a crucial step in the history of the Smithsonian Institution was taken that year by separating the National Gallery of Art from the National Museum and making the former a distinct unit, with Dr. Holmes as its first Director.

The important part played by art throughout Holmes's earlier career has already been dwelt upon and is particularly evidenced in the panoramic views prepared by him for the Atlas of Colorado and in his volume on Mexican ruins. Mention should also be made of some delightful humorous sketches dating from the period of his explorations in the west. The same artistic taste is evident in his paper on "Aboriginal Pottery of the Eastern United States" and in other of his Bureau publications. He supplied the well-known vignette appearing on the title-pages of all publications of the Bureau of American Ethnology. His work in the art colony at Munich has been touched upon.

After his return from Chicago and while continuing to occupy his house on Belmont St., Washington, D. C., Holmes spent his summers, when not in the field, largely at his summer home, which he refers to as "my charming little place, Holmescroft," near Rockville, Md., where he continued to exercise his irrepressible artistic tastes. In 1909 he was elected president of the newly organized National Society of Fine Arts, and he represented the National Gallery of Art at the Annual Convention of the American Federation of Arts, May 15-16, 1913, of which organization he was also a member. From 1914 until 1928 he was President of the Water Color Club of Washington and he was also President of the Society of Washington Artists.

In 1926, in Dr. Holmes's eightieth year, an infection starting in the toes of his left foot made a surgical operation necessary and the surgeon discovered it had extended so far that it was

necessary to keep Holmes under the anesthetic longer than had been intended and to remove his leg above the knee. His endurance of this ordeal and rapid recovery testified to his excellent physical condition and superb vitality, while his uniform cheerfulness both in anticipation of it and during his convalescence were equally remarkable. He was soon busily at work again and continued actively engaged at his desk for six years more. On the occasion of his eightieth birthday which occurred a few months after his operation he was presented with a letter signed by his friends and associates in the Smithsonian Institution. June 30, 1932, he finally resigned his position as Director of the National Gallery of Art, and removed to Royal Oak, Mich., to live with his son, and there on his next birthday he was again remembered in a letter of congratulation signed with the names of the various members of the staff of the Smithsonian Institution and former associates of the National Museum and the Bureau of American Ethnology. His death occurred on April 20, 1933.

IV

The following honors and positions of honor were bestowed upon Dr. Holmes in addition to those already noted:

1876. Corresponding Member of the Academy of Natural Sciences of Philadelphia.
1891. Secretary of Section H, American Association for the Advancement of Science.
1892. Vice-President of Section H, American Association for the Advancement of Science; and again in 1909.
1897. Honorary Fellow of the Anthropological Institute of Great Britain and Ireland.
1899. Member of the American Philosophical Society of Philadelphia.
1899. Corresponding Member of the American Institute of Architects.
1900. Corresponding Member New York Academy of Sciences.
1900-02. President Anthropological Society of Washington.
1903. Appointed Commissioner of the United States on the International Commission of Archaelogy and Ethnology.
1903. Corresponding Member Die Berliner Gesellschaft für Anthropologie, Ethnologie and Urgeschichte.
1903. Corresponding Member Svanska Sallskapet fur Anthropologi och Geografi.
1904. Honorary Member Davenport Academy of Sciences.
1904. Vice-President Fourteenth International Congress of Americanists.

1905. (April 20.) Elected a Member of the National Academy of Sciences.
1905. Elected a Member of the American Antiquarian Society.
1907. Honorary Member Universidad de La Plata.
1909. President American Anthropological Association.
1909. Delegate of the National Academy of Sciences to the Fiftieth Anniversary of the Americn Institute of Architects.
1915. Chairman of the Organizing Committee of the Nineteenth International Congress of Americanists and the Pan-American Congress, Acting President of the Congress of Americanists, delegate of the United States to the Pan-American Congress and Chairman of the Section of Anthropology of the same.
1916. Corresponding Member Academia Nacional de Historia of the Republic of Colombia.
1916. Appointed by President Wilson a member of the National Research Council.
1917-18. President of the Washington Academy of Sciences.
1919. Life Member of the National Geographic Society.
1926. Honorary Member of the American Institute of Architects.
1926. Honorary Member of the French Alpine Club.
1928. Honorary President of the Washington Water Color Club, (until his death).
1930. Honorary Member of the Washington Academy of Sciences.
1933. Honorary Member of the Anthropological Society of Washington.

Oil paintings of Dr. Holmes by William Spencer Bagdatopaulos and E. Hodgson Smart, and a portrait bust by Moses Wainer Dykaar are in the possession of the National Gallery of Art.

V

The esteem in which Dr. Holmes was held in the world of art is attested by the positions to which he was elected and the attention his paintings received whenever he exhibited. During the latter part of his life he was universally looked up to as the dean among Washington artists. Miss Leila Mechlin, the well-known art critic, speaks of him as "a brilliant technician," and refers to the water color sketches which he brought back from South America in 1909 as "an amazing collection . . . crisply painted, and with an assurance and swiftness of touch which has seldom been excelled."

Turning to appreciation on the part of scientists, we find Sir Archibald Geikie declaring that his pictures of the scenery of the far west of the United States "are by far the most remark-

able examples yet attained of the union of artistic effectiveness with almost diagrammatic geological distinctness and accuracy." Jones and Field, in their paper on the Grand Canyon of the Yellowstone prepared in 1929, say: "The report of 1878 is replete with careful observations and beautifully accurate drawings by this master artist of geological subjects and the scientific interpretation of scenery."

As has been noted above, Holmes, during his explorations in the Colorado Valley in 1873, observed and correctly interpreted the structure and origin of a peak in the West Elk Range known as Ragged Mountain. In 1877 Gilbert noted the same thing independently in the Henry Mountains and discovered that it was a characteristic of many other peaks of the region. Gilbert made detailed studies of these and gave to this type of mountain building the name "laccolitic" by which it is now well known. Gilbert fully recognized the contribution made by Holmes to this hypothesis, named a peak after him, and in commenting on his brilliant junior associate, says: "All of Mr. Holmes's work is distinguished by care in observation and caution in deduction."

Though Dr. Holmes had singularly few contacts with the living Indians in spite of his seven years' service as Chief of the Bureau of American Ethnology, he was profoundly interested in their technical productions, especially their ceramics, and objects made by them of shell and stone. His studies of textiles were based almost entirely on museum specimens, and it is to be noted that his greatest work along these lines was in the aboriginal lithic industry and the potter's art of the eastern United States, the one dead and the other rapidly dying. This part of his work, therefore, lacked the control which might have been supplied by direct observations of native artisans, but in spite of that limitation it was of outstanding character. The published section of his Handbook of American Antiquities is the standard treatise on primitive American lithic industries, and all later archeologists have used his map of the distribution of pottery types as a basis.

These treatises will probably remain of more permanent, as they certainly are of more obvious, value than others upon which he himself laid most emphasis. Thus he regarded his opposition to, and virtual explosion of, the early theory of a paleolithic

period in America as one of his great accomplishments, and it did indeed exert a wholesome, restraining influence over archeologic thought, but men seldom attain permanent fame for their negative accomplishments, and Holmes's contribution here did little more than shorten the pathway of his contemporaries and save them some useless and wasteful meanderings.

Another remark of his probably introduces us more intimately into the nature of his greatest contribution to anthropology in America. In 1916 he said: "The classification and installation of these [Museum] collections, although still far from complete, is probably the most important single achievement of my archeological career." This statement applied, of course, to one museum, but it emphasizes his classificatory tendency which, when as highly developed as in his own case, involves a sense of proportion, of coordination and subordination, which are the equipment of the great scientific or artistic organizer. In this faculty of artistic arrangement lay his preeminence as a museum man. The same quality was exhibited in the arrangement and indexing of his own notes and manuscripts and in the synthesis of documents, photographs, and sketches bearing upon his career into sixteen bound volumes, neatly assembled and carefully systematized, indexed, and annotated which make the task of any biographer a joy. His critical work was probably incidental to this enthusiasm for classification guided by a wonderful sense of balance. Intelligent criticism is itself constructive in that it limits the field along which constructive work must proceed, and classification is the necessary preliminary to any investigation of causes. Thus Holmes not only made contributions to science in geology and anthropology, but he prepared the way for discoveries by others. He was distinguished as a geologist, as an archeologist, as a student of the lithic and ceramic industries of our American Indians, and as an artist, and he was a superlatively great illustrator of scientific subjects. Moreover, he was a very human and very lovable companion and friend to those who had the pleasure of an intimate acquaintance with him.

BIBLIOGRAPHY

Compiled by Ella Leary

Librarian of the Bureau of American Ethnology

1875

1. First ascent of the Mountain of the Holy Cross, Colorado. Expedition of 1874. Christian Weekly, May 1, 1875.

1876

2. Report on the geology of the north-western portion of the Elk range. Eighth Annual Report, U. S. Geological and Geographical Survey of the Territories, 1874: 59-71, Washington, 1876.
3. A notice of the ancient ruins of southwestern Colorado, examined during the summer of 1875. Bull. U. S. Geological and Geographical Survey of the Territories, II: 3-24, Washington, 1876.

1877

4. Report on the geology of the district examined by the suothwestern or San Juan division during the season of 1875. Ninth Annual Report, U. S. Geological and Geographical Survey of the Territories, 1875: 237-276, Washington, 1877.

1878

5. Report on the geology of the Sierra Abajo and West San Miguel mountains. Tenth Annual Report, U. S. Geological and Geographical Survey of the Territories, 1876; 187-195, Washington, 1878.
6. Report on the ancient ruins of southwestern Colorado, examined during the summers of 1875 and 1876. Ibid.: 383-408.

1880

7. Fossil forests of the volcanic tertiary formations of the Yellowstone National Park. Bull. U. S. Geological and Geographical Survey of the Territories, 1879-80, V: 125-132, Washington, 1880.

1881

8. Glacial phenomena in the Yellowstone Park. American Naturalist, XV: 203-208, Philadelphia, 1881.

1883

9. Report on the geology of the Yellowstone National Park. Twelfth Annual Report, U. S. Geological and Geographical Survey of the Territories, 1878, II: 1-57, Washington, 1883.
10. Art in shell. Transactions, Anthropological Society of Washington, 1882-1883, II: 94-119, Washington, 1883.
11. The use of the cross symbol by the ancient Americans. Ibid.: 161-172.

12. Art in shell of the ancient Americans. Second Annual Report, Bureau of American Ethnology, 1880-81: 179-305, Washington, 1883.

1884

13. Prehistoric textile fabrics of the United States, derived from impressions on pottery. Third Annual Report, Bureau of American Ethnology, 1881-82: 393-425, Washington, 1884.
14. Eccentric figures from southern mounds. Science, III: 436-438, Cambridge, Mass., 1884.
15. Appearance of the cyclone cloud at Rochester, Minn., 1883. Ibid.: 304.
16. Burial-masks of the ancient Peruvians. Ibid., IV: 10-11.
17. Illustrated catalogue of a portion of the collections made by the Bureau of American Ethnology during the field season of 1881. Third Annual Report, Bureau of American Ethnology, 1881-82: 427-510, Washington, 1884.

1885

18. Report [of the Geologist] to the Director of the United States Geological Survey, 1884-85. Sixth Annual Report, U. S. Geological Survey, 1884-85: 94-97, Washington, 1885.
19. Monoliths of San Juan Teotihuacan, Mexico. American Journal of Archaeology, I: 361-371, Baltimore, 1885.
20. Examples of iconoclasm by the conquerors of Mexico. American Naturalist, XIX: 1031-1037, Philadelphia, 1885.
21. Evidences of the antiquity of man on the site of the City of Mexico. Transactions, Anthropological Society of Washington, III: 68-81, Washington, 1885.
22. Origin and development of form and ornament in ceramic art. [Abstract.] Ibid.: 112-114. [See No. 30.]
23. [Quoted on] The glaciers in the Rocky Mountains. Fifth Annual Report, U. S. Geological Survey, 1883-84: 344-347, Washington, 1885.

1886

24. The trade in spurious Mexican antiquities. Science, VII: 170-172, 264, New York, 1886.
25. Sketch of the great Serpent mound. Ibid.: VIII:: 624-628, New York, 1886.
26. Textile art in prehistoric archaeology. American Antiquarian, VIII: 261-266, Chicago, 1886.
27. Report on the section of American prehistoric pottery in the United States National Museum. Annual Report, U. S. National Museum, 1885 pt. 2: 69, Washington, 1886.
28. Pottery of the ancient Pueblos. Fourth Annual Report, Bureau of American Ethnology, 1882-83: 257-360, Washington, 1886.
29. Ancient Pottery of the Mississippi Valley. Ibid.: 361-436.

30. Origin and development of form and ornament in ceramic art. Ibid.: 437-465. [See No. 22.]
31. Ancient pottery of the Mississippi Valley. Proceedings, Davenport Academy of Natural Sciences, 1882-84, IV: 123-196, Davenport, Iowa, 1886.

1887

32. The use of gold and other metals among the ancient inhabitants of Chiriqui Isthmus of Darien. Bull. 3, Bureau of American Ethnology, Washington, 1887. 27 pp.

1888

33. Ancient art of the province of Chiriqui, Colombia. Sixth Annual Report, Bureau of American Ethnology, 1884-85: 13-187, Washington, 1888.
34. A study of the textile art in its relation to the development of form and ornament. Ibid.: 189-252.
35. Report [of the Geologist-in-charge] to the Director of the United States Geological Survey 1885-86. Seventh Annual Report, U. S. Geological Survey, 1885-86: 136-137, Washington, 1888.
36. Use of gold and other metals in ancient Chiriqui. Jeweler's Circular and Horological Review, XIX: 34; 37-38; 65-68; 88; 91-92, New York, 1888.

1889

37. Textile fabrics of ancient Peru, Bull. 7, Bureau of American Ethnology, Washington, 1889. 17 pp.
38. Report [of the Geologist-in-charge] to the Director of the United States Geological Survey, 1886-87. Eighth Annual Report, U. S. Geological Survey, 1886-87, pt. 1: 202-203, Washington, 1889.
39. Report [of the Geologist-in-charge] to the Director of the United States Geological Survey, 1887-88. Ninth Annual Report, U. S. Geological Survey, 1887-88. 143-144, Washington, 1889.
40. On some spurious Mexican antiquities and their relation to ancient art. Annual Report, Smithsonian Institution, 1886, pt. 1: 319-334, Washington, 1889.
41. [Review of] Pitt Rivers' Excavations in Cranborne Chase, near Rushmore, on the borders of Dorset and Wilts, 1880-88. Vol. II. Printed privately, 1888. American Anthropologist, II: 172, Washington, 1889.
42. Pottery of the Potomac tide-water region. Ibid.: 246-252.
43. Debasement of Pueblo art. Ibid.: 320.
44. Archaeological collections from Alabama. Ibid.: 350.

1890

45. A quarry workshop of the flaked-stone implement makers in the District of Columbia. American Anthropologist, III: 1-26, Washington, 1890.

46. The Potomac valley as a field for archaeologic research. Ibid.: 26.
47. On the evolution of ornament, an American lesson. Ibid.: 137-146.
48. A West Virginia rock shelter, Ibid.: 217-223.
49. Recent work in the quarry workshops of the District of Columbia. Ibid.: 224-225.
50. Excavations in an ancient soapstone quarry in the District of Columbia. Ibid.: 321-330.
51. Collections of the Missouri Historical Society. Ibid.: 384.
52. Report on the department of American aboriginal pottery in the United States National Museum, 1888. Annual Report, U. S. National Museum, 1888. 105, Washington, 1890.
53. Report [of the Geologist-in-charge] to the Director of the United States Geological Survey, 1888-1889. Tenth Annual Report, U. S. Geological Survey, 1888-89, pt. 1: 189-190, Washington, 1890.
54. On the evolution of ornament, an American lesson. [Abstract.] Proceedings Thirty-eighth Meeting, American Association for the Advancement of Science, Toronto, August, 1889: 363, Salem, 1890.

1891

55. Manufacture of stone arrow-points. American Anthropologist, IV: 49-58; Washington, 1891.
56. Thruston tablet. Ibid.: 161-165.
57. Aboriginal novaculite quarries in Garland County, Arkansas. Ibid.: 313-316.
58. Report on the department of American prehistoric pottery in the United States National Museum. Annual Report, U. S. National Museum, 1890. 135-136, Washington, 1891.
59. Aboriginal stone implements of the Potomac valley. [Abstract.] Proceedings, Thirty-ninth Meeting, American Association for the Advancement of Science, Indianapolis, August, 1890: 391, Salem, 1891.

1892

60. Report as delegate to Congrès Géologique International. American Anthropologist, V: 50-51, Washington, 1892.
61. Studies in aboriginal decorative art. I. Stamped ornament of South Appalachian earthenware. Ibid.: 67-72.
61a. Studies in aboriginal decorative art. II. The rocking stamp or roulette in pottery decoration. Ibid.: 149-152.
62. On the distribution of stone implements in the tidewater province. [Abstract.] Proceedings, Fortieth Meeting, American Association for the Advancement of Science, Washington, August, 1891: 366, Salem, 1892.
63. Aboriginal novaculite quarries in Arkansas. [Abstract.] Ibid.: 366-367.

64. Evolution of the aesthetic. Proceedings, Forty-first Meeting, American Association for the Advancement of Science, Rochester, August, 1892: 239-255, Salem, 1892.
65. Sacred pipestone quarries of Minnesota and ancient copper mines of Lake Superior. [Abstract.] Ibid.: 277-279.
66. Aboriginal quarries of flakable stone and their bearing upon the question of palaeolithic man. [Abstract.] Ibid.: 279-280.
67. On the so-called palaeolithic implements of the upper Mississippi. [Abstract.] Ibid.: 280-281.
68. Report on the department of American aboriginal pottery in the United States National Museum, 1891. Annual Report, U. S. National Museum, 1891: 145, Washington, 1892.
69. Notes upon some geometric earthworks, with contour maps. American Anthropologist, V: 363-373, Washington, 1892.
70. Modern quarry refuse and the paleolithic theory. Science, XX: 295-297, New York, 1892. [See No. 77.]

1893

71. Report on the department of American aboriginal pottery in the United States National Museum. Annual Report, U. S. National Museum, 1892: 109, Washington, 1893.
72. Distribution of stone implements in the tidewater country. American Anthropologist, VI: 1-14, Washington, 1893. [Reprinted in the Archaeologist, I: 41-50, Waterloo, Indiana, 1893.]
73. Geographic nomenclature of the District of Columbia. Ibid.: 29-53.
74. [Review of] Pitt Rivers' Excavations in Bokerly and Wansdyke, Dorset and Wilts. 1888-1891. With observations on the human remains, by J. G. Garson. Vol. III [London]. 1892. Ibid.: 344.
75. The World's Fair Congress of Anthropology. Ibid.: 423.
76. Obituary of Charles Colcock Jones. Ibid.: 457-458.
77. Modern quarry refuse and the paleolithic theory. The Archaeologist, I: 21-27, Waterloo, Indiana, 1893. [Reprint of No. 70.]
78. Traces of glacial man in Ohio. Ibid.: 161-170. [See No. 81.]
79. Gravel man and paleolithic culture; a preliminary word. Science, XXI: 29-30, New York, 1893.
80. Are there traces of glacial man in the Trenton gravels? Journal of Geology, I: 15-37, Chicago, 1893.
81. Traces of glacial man in Ohio. Ibid., 147-163. [See No. 78.]
82. Vestiges of early man in Minnesota. American Geologist, XI: 219-240, Minneapolis, 1893. [See No. 89.]

1894

83. An ancient quarry in Indian Territory. Bull. 21, Bureau of American Ethnology, Washington, 1894. 19 pp.

84. Introductory note [to archeologic investigation in James and Potomac valleys, by Gerard Fowke]. Bull. 23, Bureau of American Ethnology: 7-8, Washington, 1894.
85. Earthenware of Florida; Collections of Clarence B. Moore. Journal, Academy of Natural Sciences of Philadelphia, 2d series, X: 105-128, Philadelphia, 1894.
86. Order of development of the primal shaping arts. Proceedings, Forty-second Meeting, American Association for the Advancement of Science, Madison, August, 1893: 289-300, Salem, 1894.
87. Natural history of flaked stone implements. Memoirs, International Congress of Anthropology: 120-139, Chicago, 1894.
88. Caribbean influence in the prehistoric art of Southern states. American Anthropologist, VII: 71-79, Washington, 1894.
89. Vestiges of early man in Minnesota. The Archaeologist, II: 65-79, Waterloo, Indiana, 1894. [See No. 82.]

1895

90. Archaeological studies among the ancient cities of Mexico. Publications, Field Columbian Museum, Anthropological series, I: 338, Chicago, 1895-1897.

1896

91. Prehistoric textile art of eastern United States. Thirteenth Annual Report, Bureau of American Ethnology, 1891-92: 3-46, Washington, 1896.

1897

92. Stone implements of the Potomac-Chesapeake tidewater province. Fifteenth Annual Report, Bureau of American Ethnology, 1893-94: 13-152, Washington, 1897.
93. Preservation and decorative features of Papuan crania. Publications, Field Columbian Museum, Anthropological series, II: 41-48, Chicago, 1897.
94. Primitive man in the Delaware valley. Science, VI: 824-829, New York, 1897. [See No. 97.]

1898

95. Anthropological exhibit of the U. S. National Museum at the Omaha Exposition. Science, VIII: 37-40, New York, 1898.
96. The building of a Zapotec city. Proceedings, Forty-sixth Meeting, American Association for the Advancement of Science, Detroit, August, 1897: 340, Salem, 1898.
97. Primitive man in the Delaware valley. Ibid.: 364-370. [See No. 94.]
98. Museum presentation of anthropology. Proceedings, Forty-seventh Meeting, American Association for the Advancement of Science, Boston, August, 1898: 485-488, Salem, 1898.

1899

99. Preliminary revision of the evidence relating to auriferous gravel man in California. American Anthropologist, n. s., I: 107-121, 614-645, New York, 1899. [See No. 105.]

1900

100. Report on the department of anthropology for the year 1897-1898. Annual Report, U. S. National Museum, 1898: 19-33, Washington, 1900.
101. Ancient monuments of Yucatan. Monumental Records, I: 140-142, New York, 1900.
102. The ancient Aztec obsidian mines of the State of Hidalgo, Mexico. [Abstract.] Proceedings, Forty-ninth Meeting, American Association for the Advancement of Science, New York, June, 1900: 313, Easton, Pa., 1900.
103. Remarks on Frank Hamilton Cushing. American Anthropologist, n. s., II: 356-360, New York, 1900.
104. Obsidian mines of Hidalgo, Mexico. Ibid.: 405-416.

1901

105. Review of the evidence relating to auriferous gravel man in California. First paper. Annual Report, Smithsonian Institution, 1899: 419-472, Washington, 1901. [See No. 99.]
106. Report on the department of anthropology for the year 1898-1899. Annual Report, U. S. National Museum, 1899: 17-24, Washington, 1901.
107. Use of textiles in pottery making and embellishment. American Anthropologist, n. s., III: 397-403, New York, 1901.
108. Aboriginal copper mines of Isle Royale, Lake Superior. Ibid.: 684-696.

1902

109. Order of development of the primal shaping arts. Annual Report, Smithsonian Institution, 1901: 501-513, Washington, 1902.
110. Flint implements and fossil remains from a sulphur spring at Afton, Indian Territory. American Anthropologist, n. s., IV: 108-129, New York, 1902. [See No. 123.]
111. Sketch of the origin, development, and probable destiny of the races of men. Ibid., 369-391.
112. [Review of] Brower's Memoirs of Explorations in the Basin of the Mississippi. Volume V, Kakabikansing. With a contributed section by N. H. Winchell. St. Paul, 1902. Ibid.: 517-520.
113. [Review of] Moore's Certain Aboriginal Remains of the Northwest Florida Coast. Part 1. Ibid.: 521-523.
114. Fossil human remains found near Lansing, Kansas. Ibid.: 743-752. [See No. 125.]

115. Classification and arrangement of the exhibits of an anthropological museum. Science, XVI: 487-504, New York, 1902. [See No. 124.]
116. Instructions to collectors of historical and anthropological specimens. Especially designed for collectors in the insular possessions of the United States, by W. H. Holmes and O. T. Mason. Bull. 39, U. S. National Museum, part Q, Washington, 1902. 16 pp.
117. Report on the department of anthropology for the year 1899-1900. Annual Report, U. S. National Museum, 1900: 21-29, Washington, 1902.
118. Anthropological studies in California. Ibid.: 155-187.

1903

119. Aboriginal pottery of the eastern United States. Twentieth Annual Report, Bureau of American Ethnology, 1898-1899: 1-201, Washington, 1903.
120. Report on the department of anthropology for the year 1900-1901. Annual Report, U. S. National Museum, 1901: 51-61, Washington, 1903.
121. The exhibit of the department of anthropology. Ibid.: 200-218.
122. Report on the exhibit of the United States National Museum at the Pan-American Exposition, Buffalo, New York, 1901. By F. W. True, W. H. Holmes, and G. P. Merrill. Ibid., 177-231.
123. Flint implements and fossil remains from a sulphur spring at Afton, Indian Territory. Ibid.: 237-252. [See No. 110.]
124. Classification and arrangement of the exhibits of an anthropological museum. Ibid.: 253-278. [See No. 115.]
125. Fossil human remains found near Lansing, Kansas. Annual Report, Smithsonian Institution, 1902: 455-462, Washington, 1903. [See No. 114.]
126. Traces of aboriginal operations in an iron mine near Leslie, Missouri. American Anthropologist, n. s., 503-507, Lancaster, Pa., 1903. [See No. 130.]
127. Shell ornaments from Kentucky and Mexico. Smithsonian Miscellaneous Collections, vol. XLV (Quarterly Issue, Vol. 1): 97-99, Washington, 1903. [Reprinted in Scientific American Supplement, LVIII: 23828, New York, 1904.]

1904

128. Report on the department of anthropology for the year 1901-1902. Annual Report, U. S. National Museum, 1902: 53-58, Washington, 1904.
129. Report of the [Chief of the] Bureau of American Ethnology to the Secretary of the Smithsonian Institution [for the fiscal year ending June 30, 1903]. Annual Report, Smithsonian Institution, 1903 :34-48, Washington, 1904.

130. Traces of aboriginal operations in an iron mine near Leslie, Mo Ibid.: 723-726. [See No. 126.]
131. The exhibits of the Smithsonian Institution in the Government Building [at the St. Louis Exposition]. American Anthropologist, n. s., VI: 754, Lancaster, Pa., 1904.
132. [Letter as Chief of the Bureau of American Ethnology, dated Washington, November 19, 1904, addressed to Edgar L. Hewett, respecting the preservation of antiquities.] *In* Hewett, Edgar L., Circular Relating to Historic and Prehistoric Ruins: 16, Washington, 1904. Also in Hewett, Edgar L., Government Supervision of Historic and Prehistoric Ruins: 10-11 of reprint, New York, 1904.

1905

133. Report of the [Chief of the] Bureau of American Ethnology to the Secretary of the Smithsonian Institution [for the fiscal year ending June 30, 1904]. Annual Report, Smithsonian Institution, 1904: 46-54, Washington, 1905.
134. Report on the Congress of Americanists held at Stuttgart, Germany, August 18-23, 1904. Smithsonian Miscellaneous Collections, XLVII (Quarterly Issue, vol. II): 391-395, Washington, 1905.
135. Contributions of American archaeology to human history. Ibid., pp. 412-420. Published also in Annual Report, Smithsonian Institution, 1904: 551-558, Washington, 1905.
136. [Review of] Farrand's The American Nation: A History. Vol. II. Basis of American History, 1500-1900. New York, 1904. American Anthropologist, n. s., VII: 114-117, Lancaster, Pa., 1905.
137. Notes on the antiquities of Jemez valley, New Mexico. Ibid.: 198-212.

1906

138. Report of the [Chief of the] Bureau of American Ethnology to the Secretary of the Smithsonian Institution [for the fiscal year ending June 30, 1905]. Annual Report, Smithsonian Institution, 1905: 40-52, Washington, 1906.
139. Decorative art of the aborigines of northern America. Anthropological Papers written in Honor of Franz Boas: 179-188, New York, 1906.
140. Certain notched or scalloped stone tablets of the mound-builders. American Anthropologist, n. s., VIII: 101-108, Lancaster, Pa., 1906.

1907

141. Twenty-fourth Annual Report of the [Chief of the] Bureau of American Ethnology to the Secretary of the Smithsonian Institution [for the fiscal year 1902-03]. Washington, 1907. xl pp.
142. Twenty-fifth Annual Report of the [Chief of the] Bureau of American Ethnology to the Secretary of the Smithsonian Institution [for the fiscal year 1903-04]. Washington, 1907. xxix pp.

143. Report of the [Chief of the] Bureau of American Ethnology to the Secretary of the Smithsonian Institution [for the fiscal year ending June 30, 1906]. Annual Report, Smithsonian Institution, 1906: 47-50, Washington, 1907.

144. [Articles on] Abrading implements, Actinolite, Adzes (with Gerard Fowke), Amber, Anchor stones, Andesite, Antiquity, Anvils, Archaeology, Architecture, Argillite, Arrowheads (with Gerard Fowke), Art, Axes (with Gerard Fowke), Baking stones, Banner stones, Basalt, Bells, Bird-stones, Boat-stones (with Gerard Fowke), Bone-work, Bureau of American Ethnology, Cache disks and blades, Calaveras Man, Calcite, Catlinite (Red pipestone), Caves and rock shelters, Celts (with Gerard Fowke), Chalcedony (with G. P. Merrill), Chisels (with Gerard Fowke), Chlorite, Cinnabar, Cliff-dwellings, Cones (with Gerard Fowke), Copper, Cross, Daggers, Duck tablets, Engraving, Flakes, Flaking implements, Flint (with Gerard Fowke), Flint disks, Footprint sculptures, Galena, Gold, Gorgets, Granite, Graphic art, Gypsum, Hammers, Hatchets, Hematite, Hemispheres, Hoes and spades (with Gerard Fowke), Hook-stones, Iron, Jasper, Jet, Knives, Lignite (Anthracite, Cannel coal), Marble, Metalwork, Metate, Mica, Mines and quarries, Mortars, Mosaic, Mullers. *In* Handbook of American Indians, Bull. 30, Bureau of American Ethnology, pt. 1, Washington, 1907. [See No. 162.]

145. Aboriginal shell-heaps of the middle Atlantic tidewater region. American Anthropologist, n. s. IX: 113-128, Lancaster, Pa., 1907.

146. [Review of] Mills' Certain Mounds and Village Sites in Ohio. Vol. 1. Columbus, 1907. Ibid.: 614-618.

147. On a nephrite statuette from San Andrés Tuxtla, Vera Cruz, Mexico. Ibid.: 691-701. [See No. 179.]

148. [Review of] Moore's Moundville Revisited. Crystal River Revisited. Mounds of the Lower Chattahoochee and Lower Flint Rivers. Notes on the Ten Thousand Islands, Florida. Ibid.: 741-742.

149. On the origin of the cross symbol. Proceedings, American Antiquarian Society, n. s., XVIII: 98-105, Worcester, Mass., 1907.

1908

150. Twenty-sixth Annual Report of the [Chief of the] Bureau of American Ethnology to the Secretary of the Smithsonian Institution [for the fiscal year 1904-05]. Washington, 1908. xxxi pp.

151. Report of the [Chief of the] Bureau of American Ethnology to the Secretary of the Smithsonian Instituiton [for the fiscal year ending June 30, 1907]. Annual Report, Smithsonian Institution, 1907: 48-55, Washington, 1908.

152. [Review of] Saville's Contributions to South American Archeology. The George G. Heye Expedition. The Antiquities of Manabi, Ecuador. A Preliminary Report. New York, 1907. American Anthropologist, n. s., X: 122-128, Lancaster, 1908.
153. [Review of] Hartman's Archeological Researches on the Pacific Coast of Costa Rica. Pittsburgh, 1907. Ibid.: 128-133.
154. The tomahawk. Ibid.: 264-276.

1909

155. Report of the [Chief of the] Bureau of American Ethnology to the Secretary of the Smithsonian Institution [for the fiscal year ending June 30, 1908]. Annual Report, Smithsonian Institution, 1908: 44-52, Washington, 1909.
156. Biographical memoir of Lewis Henry Morgan, 1818-1881. Read before the National Academy of Sciences, November 20, 1907. Biographical Memoirs of the National Academy of Sciences, VI: 219-239, Washington, 1909.
157. First Pan-American scientific congress, held in Santiago, Chile, December 25, 1908-January 6, 1909. Science, n. s., XXIX: 441-448. New York, 1909. [See No. 161.]

1910

158. Report of the [Chief of the] Bureau of American Ethnology to the Secretary of the Smithsonian Institution [for the fiscal year ending June 30, 1909]. Annual Report, Smithsonian Institution, 1909: 40-48, Washington, 1910.
159. Some problems of the American race. American Anthropologist, n. s., XII: 149-182, Lancaster, Pa., 1910.
160. Remarks on the study of aboriginal American history. Proceedings, Mississippi Valley Historical Association, 1908-1909, Vol. II: 182-189, Cedar Rapids, Iowa, 1910.
161. The first Pan-American scientific congress, held in Santiago, Chile, December 25, 1908-January 6, 1909. Annual Report, Smithsonian Institution, 1909: 86-95, Washington, 1910. [See No. 157.]
162. [Articles on] Nampa image, Neolithic age, Nephrite, Notched plates, Novaculite, Obsidian, Ornament, Painting, Paleolithic implements, Pearls, Pecking implements, Pectolite, Perforated stones, Pestles, Picks, Pierced tablets, Pile dwellings, Plummets, Polishing implements, Porpyhry, Pottery, Problematical objects, Pyrite or Iron Pyrites, Quartz, Quartzite, Receptacles, Rhyolite, Saws, Schist, Scrapers, Sculpture and carving, Serpentine, Shell, Shell-work, Shell-heaps, Sienite, Silver, Sinkers, Slate, Spade-stones, Spine-back stones, Steatite, Stonework, Teshoa, Tomahawk, Trachite, Turquoise, Wedges. *In* Handbook of American Indians, Bull. 30, Bureau of American Ethnology, pt. 2, Washington, 1910. [See No. 144.]

1911

163. Twenty-seventh Annual Report of the [Chief of the] Bureau of American Ethnology to the Secretary of the Smithsonian Institution [for the fiscal year 1905-06]. Washington, 1911, 14 pp.

1912

164. Twenty-eighth Annual Report of the [Chief of the] Bureau of American Ethnology to the Secretary of the Smithsonian Institution [for the fiscal year 1906-07]. Washington, 1912. 21 pp.
165. Stone implements of the Argentine littoral. Bull. 52, Bureau of American Ethnology: 125-151, Washington, 1912.
166. Bearing of archeological evidence on the place of origin and on the question of the unity or plurality of the American race. American Anthropologist, n. s., XIV: 30-36, Lancaster, Pa., 1912.

1913

167. The relations of archeology to ethnology. [Discussion.] Ibid.: XV: 566-567. Lancaster, Pa., 1913.

1914

168. Areas of American Culture characterization tentatively outlined as an aid in the study of the antiquities. American Anthropologist, n. s., XVI: 413-446, Lancaster, Pa., 1914. Reprinted in: Anthropology of North America, by Franz Boas and others, New York, 1915.
169. Masterpieces of aboriginal American art. I.—Stucco work. Art and Archaeology, I: 1-12, Washington, 1914.
170. Masterpieces of aboriginal American art. II.—Mosaic work, minor examples. Ibid.: 91-102.

1915

171. Problem of the twin cups of San Juan Teotihuacan, Mexico. Ibid.: 210.
172. Masterpieces of aboriginal American art. III.—Mosaic work, major examples. Ibid.: 243-255.
173. Ancient America at the Panama-California exposition, San Diego. Ibid.: II: 30-31, Washington, 1915.
174. Introduction [to Ancient America at the Panama-California exposition, by Edgar L. Hewett]. Ibid.: 65-66.
175. Thirtieth Annual Report of the [Chief of the] Bureau of American Ethnology to the Secretary of the Smithsonian Institution [for the fiscal year 1908-09]. Washington, 1915, 24 pp.
176. The place of archaeology in human history. [Abstract.] Nineteenth International Congress of Americanists, December 27-31, Washington, 1915. [See No. 185.]

1916

177. Dighton Rock. Art and Archaeology, III: 53-55, Washington, 1916.
178. Masterpieces of aboriginal American art. IV.—Sculpture in the round. Ibid.: 71-85.
179. The oldest dated American monument, a nephrite figurine from Mexico. Ibid.: 274-278. [See No. 147.]
180. Examples of spurious antiquities. I.—Guatemalan pottery. Ibid.: 287-288.
181. The oldest dated American monument. Bull. Pan American Union, 43: 89-93, July, 1916.
182. The great dragon of Quirigua. Annual Report, Smithsonian Institution, 1916: 447-460. Reprinted as No. 183.
183. Masterpieces of aboriginal American art. V.—The great dragon of Quirigua, Part 1. Art and Archaeology, IV, no. 6: 269-278, Washington, December, 1916.
184. A Quirigua mystery. Ibid.: 341.

1917

185. The place of archeology in human history; Proceedings, Nineteenth International Congress of Americanists, Washington, 1917: 5-11. [See No. 176.]
186. Archeological explorations in Guatemala and Honduras. Smithsonian Miscellaneous Collections, LX, no. 17: 73-76, Washington, 1917.
187. La Casa del Adivino, Uxmal, Yucatan. Art and Archaeology, VI: 17, July, 1917.

1918

188. On the antiquity of man in America. Science, n. s., 47, no. 1223, June 7, 1918.
189. Organization of the Committee on Anthropology of the National Research Council and its activities for the year 1917. American Journal of Physical Anthropology, 1, no. 1: 77-90, May 16, 1918.

1919

190. Handbook of American Antiquities. Part I—Introduction. Bull. 60, Bureau of American Ethnology, Washington, 1919.
191. Masterpieces of aboriginal American art. VI. Work of the goldsmith. Art and Archaeology, 8, no. 6, 349-360, November-December, 1919.
192. On the race history and facial characteristics of the aboriginal Americans. Smithsonian Report, 1919: 427-432.

1920

193. On the race history and facial characteristics of the aboriginal Americans. Art and Archaeology. 9, no. 2: 77-89, February, 1920.

1921

194. A ceramic masterpiece from Salvador. Ibid.: 11, 69, January-February, 1921.

1922

195. Report of the [Director of the] National Gallery of Art to the Secretary of the Smithsonian Institution [for the fiscal year ending June 30, 1921]. Annual Report, Smithsonian Institution, 1921: 42-52, Washington, 1922.
196. The National Gallery of Art. Catalogue of Collections. 1-2, Washington, 1922, 1926.

1924

197. Report of the [Director of the] National Gallery of Art to the Secretary of the Smithsonian Institution [for the year ending June 30, 1922]. Annual Report, Smithsonian Institution, 1922: 42-52, Washington, 1924.
198. Herbert Ward's achievements in the field of art. Art and Archaeology, 18: 113-125, September, 1924.

1925

199. Report of the [Director of the] National Gallery of Art to the Secretary of the Smithsonian Institution [for the fiscal year ending June 30, 1923]. Annual Report, Smithsonian Institution, 1923: 45-58, Washington, 1925.
200. Ibid. for 1923-1924. Annual Report, Smithsonian Institution, 1924: 47-56, Washington, 1925.
201. The antiquity phantom in American Archaeology. Science, n. s., 62: 256-258, September 18, 1925.

1926

202. Report of the [Director of the] National Gallery of Art to the Secretary of the Smithsonian Institution [for the fiscal year ending June 30, 1925]. Annual Report, Smithsonian Institution, 1925: 48-56, Washington, 1926.

1927

203. Ibid. for 1925-1926. Annual Report, Smithsonian Institution, 1926: 50-60, Washington, 1927.

1928

204. Installation of the W. A. Clark collection in the Corcoran Gallery of Art. Art and Archaeology, 25: 163-180, April, 1928.
205. Report of the [Director of the] National Gallery of Art to the Secretary of the Smithsonian Institution [for the fiscal year ending June 30, 1927]. Annual Report, Smithsonian Institution, 1927: 54-62, Washington, 1928.

1929

206. Ibid. for 1927-1928. Annual Report, Smithsonian Institution, 1928: 52-62, Washington, 1929.

1930

207. Ibid. for 1928-1929. Annual Report, Smithsonian Institution, 1929: 42-49, Washington, 1930.

1931

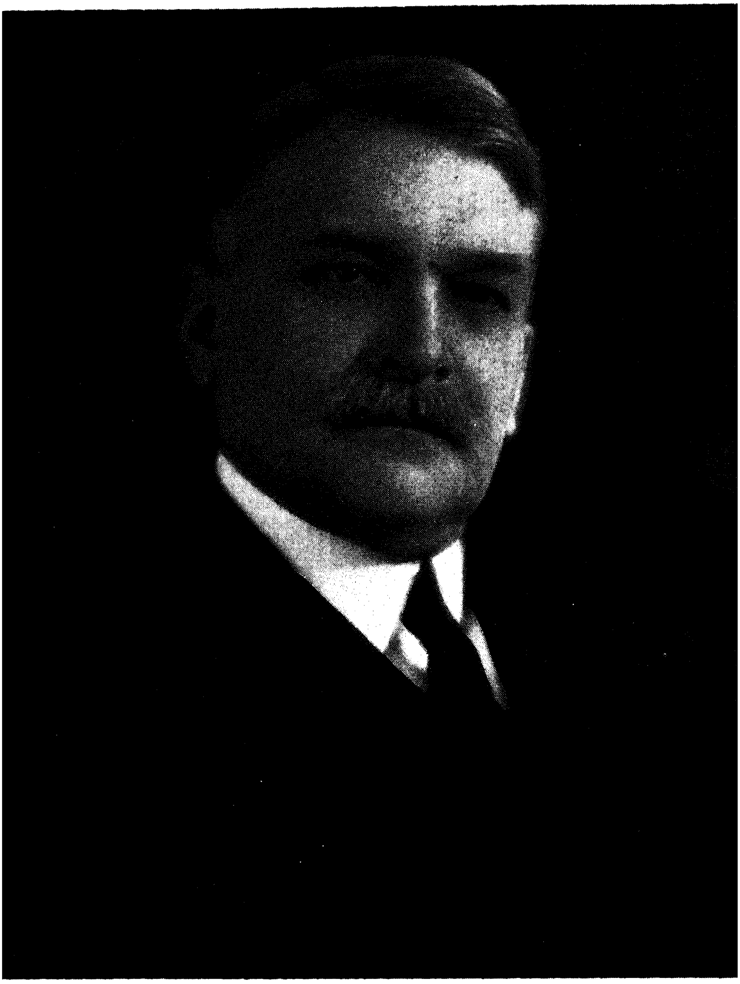
208. Ibid. for 1929-1930. Annual Report, Smithsonian Institution, 1930: 45-53, Washington, 1931.

1932

209. Ibid. for 1930-1931. Annual Report, Smithsonian Institution, 1931: 43-53, Washington, 1932.

1933

210. Ibid. for 1931-1932. Annual Report, Smithsonian Institution, 1932: 29-33, Washington, 1933.



Samuel W. Stratton

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVII—ELEVENTH MEMOIR

BIOGRAPHICAL MEMOIR

OF

SAMUEL WESLEY STRATTON

1861–1931

BY

A. E. KENNELLY

PRESENTED TO THE ACADEMY AT THE AUTUMN MEETING, 1935

SAMUEL WESLEY STRATTON

1861–1931

BY A. E. KENNELLY

Samuel Wesley Stratton was born at Litchfield, Ill., on July 18th, 1861, the son of Samuel and Mary B. (Webster) Stratton. His boyhood was spent in the open country, and he enjoyed a strong physique, with active health, throughout most of his life. He was a tireless worker and always kept long hours.

In his boyhood he showed an unusual aptitude for machines and mechanical processes. In his school days he was entrusted with the care of the machinery on his father's farm.

After finishing school, he entered the University of Illinois, where he worked his way through college, mainly by printing and photography. As a lad, he had learned to do his father's printing, and through all his life he strove to support the art and science of printing. He obtained, in 1884, the degree of B.Sc. in Mechanical Engineering, his favorite subject. In college, his physical strength might well have won for him a recognized place in field sports; but he preferred to take in its place the military course at the University of Illinois, and he graduated from that course with the rank of Captain. This training served him later in good stead.

From 1885 to 1889, he was Instructor of Mathematics and Physics at the University of Illinois, being promoted to Assistant Professor of Physics in 1889. He occupied the chair of Physics and Electrical Engineering from 1889 to 1892. During the latter year, he left the University of Illinois to become Assistant Professor of Physics at the University of Chicago, being there promoted to Associate Professor in 1895, and Professor, in 1898. His special interest lay in the direction of experimental physics, through the development of fine mechanism, and in applied physics, through engineering, towards mechanical processes. At the University of Chicago, he became associated with Michelson, the great experimental physicist. He produced with

Michelson, in 1897, a new form of harmonic analyzer, capable of analyzing a complex harmonic wave into as many as 80 components, or conversely, of synthesizing a complex harmonic wave embodying any combination of given harmonics up to 80. During the years 1892-1899, at the University of Chicago, he was actively engaged in the development of apparatus for the Ryerson Physical Laboratory, and many instruments there are monuments to his ability and skill as a designing engineer.

Commencing with his military studies at the University of Illinois, Dr. Stratton was of great service to military science throughout his life. From 1895 to 1901, he served first as Ensign, next as Lieutenant, and then as Lieutenant-Commander, in the Illinois Naval Militia. During the Spanish-American war of 1898, he served as Lieutenant in the U. S. Navy, and from 1904 to 1912 commanded the D. C. Naval Militia, with the rank of Commander. He took much interest in naval gunnery, and later at the Bureau of Standards directed various researches in internal ballistics.

On returning to Chicago at the end of 1898, Dr. Stratton was asked to go to Washington, to invite Admiral Dewey and Secretary Gage of the Treasury, to give addresses in Chicago. In his interview with Secretary Gage, the Secretary asked him many questions concerning the standard weights and measures of the country, then in the custody of the U. S. Coast and Geodetic Survey, at Washington, D. C. Stratton described how, in certain European countries, such standards were entrusted to National Physical Laboratories, and formed there the nucleus of much scientific work. This led to Stratton being invited to take the post of Superintendent of U. S. Weights and Measures, at Washington, in the Coast Survey Building, with the understanding that he would work towards the establishment of a suitable national laboratory for conserving and developing them. Stratton accepted the offer.

Thus established at Washington, Stratton drew up, with the aid of various government officers, plans for the creation and maintenance, by the Congress, of a national laboratory of standards to be situated near Washington, D. C.

Temporary offices were secured in Washington for the scien-

tific work of the new department, and a bill was drawn up for the establishment by the Congress of the National Bureau of Standards. The bill went through many vicissitudes; but was finally passed in the closing hours of the Congressional session in March 1901. It was saved from failure more than once by Stratton's ability to interest the men on Congressional committees. A site for the buildings of the new bureau was selected in the Washington suburbs near Chevy Chase, on three hectares of unbroken land, free from mechanical and electrical disturbances. In building and manning the laboratory, Stratton showed marked organizing ability. He was appointed its Director, a position he held, with great distinction, for more than twenty years.

While superintending many investigations at the Bureau, on the uses and improvements of national standards for mechanics, light, heat and electricity, Stratton found means to interest many manufacturers in the applied science of standards for industry and economical production. He showed how improved tests and standards for machinery of all kinds would reduce costs and improve production. The National Bureau of Standards became known all over the world as the home of scientific measurement, the support of high-class engineering, and the inspiration of improved manufacture. By the year 1922, the original two large laboratory buildings had grown to fourteen, with a total staff of nine hundred employees extending over some twenty hectares of land. This great organization was largely self-supporting from its services to industry. Dr. Stratton was the director and inspirer of all this work.

When the question arose of establishing a U. S. Government radio research center, Stratton succeeded in getting the Army and Navy Departments to pool their operations with those of the Bureau, for joint effectiveness and economy. He secured an appropriation for a separate building on the Bureau grounds, to serve the three departments.

In the international field of standards and their measurement, Stratton was also very successful in organizing coöperative effort. He was the American member of the International Committee of Weights and Measures, at the International Bureau of Weights and Measures, in Sèvres, near Paris, where the inter-

national meter and kilogram are deposited, and copied for world distribution. He was instrumental in extending the province of the Sèvres International Bureau from mechanical to electrical standards, and in securing funds from the Rockefeller Foundation for work on maintaining and comparing electrical standards. After the electrical conference in London, of 1908, between representatives of the various national physical laboratories, he was able to bring to the Bureau at Washington a group of electrical physical experts from England, France and Germany, to collaborate with American experts at the Bureau, for redetermining international standards of electric current, resistance and voltage. The outcome of this joint effort was of great international usefulness. He also aided in the establishment, in 1927, of the Consulting Committee on Electricity, to advise the International Committee and the Conference of Weights and Measures, towards establishing world standards for electricity and magnetism at the Sèvres Bureau. This Consultative Committee has already accomplished important world work for preparing such standards.

In 1922, Dr. Stratton was elected to the presidency of the Massachusetts Institute of Technology, Cambridge, Mass., and devoted himself, with characteristic whole-heartedness, to the administration of its affairs, which prospered notably under his direction. He emphasized the importance of research in all departments, and especially of industrial research. He also maintained close contact with the student body, and attended sympathetically to their needs. Two student dormitories were built near to the group of laboratory buildings by his special efforts. In 1930, in view of his increasing responsibilities, he recommended that the noted physicist Dr. Karl T. Compton be invited to the Presidency, Dr. Stratton becoming Chairman of the M. I. T. Corporation, a post which he held until his death.

Prof. Stratton was awarded no less than six honorary doctor's degrees during his career. His alma mater, the University of Illinois, gave him an honorary D.Eng. in 1903, and three universities gave him the honorary D.Sc.; namely, Pittsburgh, in 1903, Cambridge, England, in 1908, and Yale in 1918. Harvard University awarded him a LL.D. in 1923, and Rensselaer a

Ph.D. degree in 1924. He received the Elliott Cresson Medal of the Franklin Institute, and the Welfare Medal of the National Academy of Sciences. He was an Officer of the Legion of Honor, and an Honorary Member of two Honor Societies; viz., the Sigma Xi, in Physics, and the Tau Beta Pi, in Engineering. He was a United States Delegate to two International Electrical Congresses; that of St. Louis in 1904, and that of London in 1908.

He was a member of the following organizations:

Council of National Defense.
National Advisory Committee for Aeronautics.
Interdepartmental Board on Ice Observation and Patrol.
Standardization Committee, American Section, International Chamber of Commerce.
Federal Specifications Board.
National Screw Thread Commission.

He was also a member of a number of scientific and technical societies, of which the following may be mentioned:

National Academy of Sciences.
National Research Council.
American Philosophical Society.
American Association for the Advancement of Science.
Washington Academy of Sciences.
American Institute of Electrical Engineers.
American Society of Mechanical Engineers.
American Society for Testing Materials.
National Aeronautic Association of U. S. A.
American Physical Society.
American Engineering Standards Committee.
Optical Society of America. (Hon. Member).

In personality, he was friendly, direct and engaging, without a trace of affectation. Of medium height, he was of sturdy frame and gave the impression of considerable physical strength. His countenance was stern in repose; but animated, frank, and kindly in discussion. He was quick to perceive the abilities of those who came within his range of communication, and to organize them into coöperative effort for the purposes of applied science, without any consideration of his own personal advantage. His mind was dominated by the ideals of improving all

engineering enterprise through scientific study and research. He loved fine tools, and fine workmanship in the construction of delicate apparatus. At the Bureau of Standards North Building, he equipped a small workshop, at his own expense, with some special tools and materials for instrument work. Here he would often seek recreation, after working hours, in fashioning new instruments for special investigations.

He had a kindly disposition towards the world, in general, and to his staff, in particular. He showed no favoritism; but he would invite groups of his well tried assistants to meet with him, when off duty, on friendly terms. All his men felt that they had his sympathy and moral support. He enjoyed the friendship of a large number of applied scientists in many parts of the world, and without being interested in politics or political parties, he had a large circle of acquaintances in the administrative circles of Washington. He was liked and respected by everyone for his frankness and fair dealing.

The great American inventor and applied scientist, Thomas A. Edison, died on the morning of Sunday, October 18, 1931, at his home in Orange, New Jersey. Edison and Stratton had been close friends for many years. That same evening, Dr. Stratton prepared, at his apartment in Boston, a long telegram of condolence to the Edison family. This finished, he granted an interview to a newspaper reporter, and sitting in his parlor overlooking the Charles River, nearly opposite the Institute of Technology on the Cambridge side, he commenced dictating, seemingly in good health, a warm encomium on the life and accomplishments of Edison. After having spoken about two hundred words, without any sign of pain or fatigue, he commenced a new sentence about Edison's life. He got as far as the words: "His interests . . . . ." when his head fell forward suddenly, and he evidently lost consciousness. A physician, hastily summoned, at once pronounced Dr. Stratton dead from heart failure. Thus with dramatic painlessness, Stratton departed this life, with a eulogy of Edison on his lips.

The death notices of Edison and Stratton appeared side by side in the morning papers of Monday the 19th of October, 1931.

Dr. Stratton never married; but his "boys at the Bureau" and the students at Technology had a filial affection for him.

Testimonials to his character and accomplishments came in from all over the world. The National Bureau of Standards at Washington is virtually his monument.

PUBLISHED PAPERS OF

SAMUEL WESLEY STRATTON

Articles, reports and pamphlets

"Harmonic analyzer," by A. A. Michelson and Samuel W. Stratton. *American Journal of Science,* 1898, vol. 5, pp. 1-13.

"Circular of information of the National Bureau of Standards, no. 3. The verification of standards and standard measuring instruments." Washington, June 1, 1903. 4 pp.

"National Bureau of Standards," by Samuel W. Stratton and E. B. Rosa. *American Institute of Electrical Engineers, Proceedings,* Dec. 1905, vol. 24, pp. 1039-1090. Discussion, Jan. 1906, vol. 25, pp. 53-57.

"Metrology in relation to industrial progress." Philadelphia, Lippincott, 1912. (Reprinted from the *Journal of the Franklin Institute,* Oct. 1912, vol. 174, pp. 425-533.)

"Work of the Bureau of Standards in 1914." *Report to U. S. Secretary of Commerce,* Washington, 1914. 99 pp.

"Metric system in export trade: report to the International High Commission relative to the use of the metric system in export trade." Washington, Government Printing Office, 1916. 80 pp. (*Senate, 64th Congress, 1st session, Doc. 241.*)

"The Bureau of Standards and its relation to the United States Coast and Geodetic Survey." Washington, Government Printing Office, 1916. 18 pp. Pamphlet. (Reprinted from the *Centennial celebration of the U. S. Coast and Geodetic Survey,* Apr. 5-6, 1916.)

"Motor headlights." A discussion of a paper (by J. W. T. Walsh) by S. W. Stratton, T. Y. Baker, L. Gaster and E. Stroud. *Optical Society, Transactions,* 1921-22, pp. 256-294.

"The Effect of Science in the Evolution of Industry" (Inaugural address, *Technology Review,* July, 1923).

"The Engineer as His Employer Sees Him," February, 1926 issue of *Professional Engineer.*

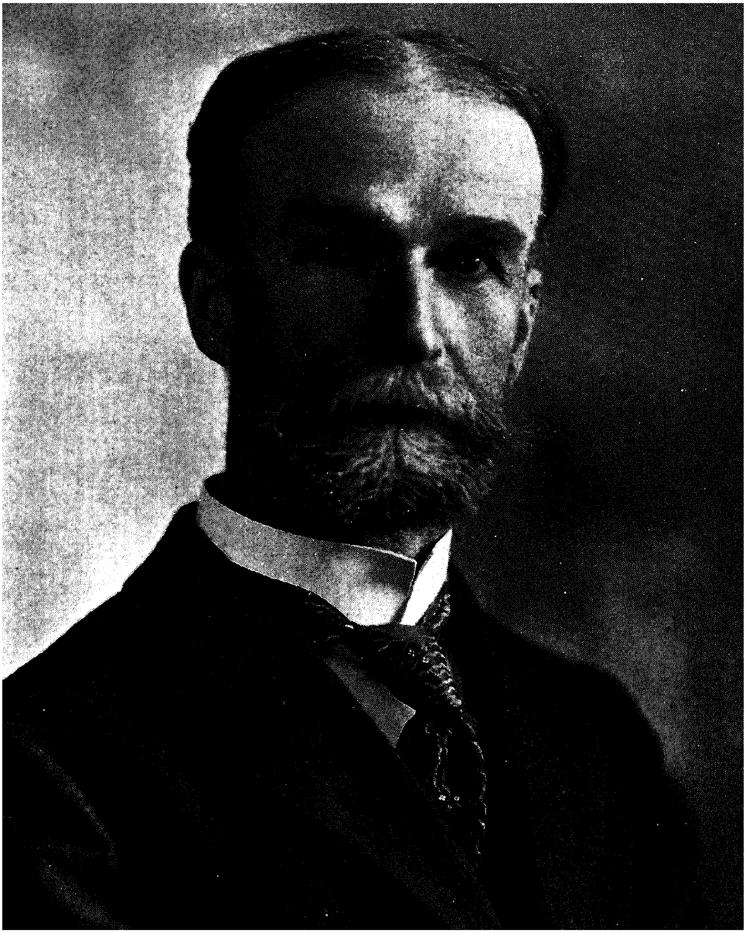
"The Importance of Science and Engineering to the Graphic Arts." *Typothetae Bulletin,* October, 1926 (Address before Education Session, Fortieth Annual Convention, Detroit, October 19, 1926.)

"Robots," by Samuel W. Stratton and F. P. Stockbridge. Excerpt from *Saturday Evening Post,* Jan. 21, 1928.

"Some thoughts about scientific research." *American Society of Heating and Ventilating Engineers' Journal,* May, 1928, vol. 34, no. 5, pp. 422-427.

"Engineering and M. I. T." *Tech. Engineering News,* Apr. 1929, vol. 10, no. 3, pp. 92, 122, 124 and 126.

"A letter to the alumni of the M. I. T. on occasion of the annual dinner of the alumni association from Samuel W. Stratton, Chairman of the Corporation; Karl Taylor Compton, Pres." (Cambridge, Mass.), M. I. T., 1931. 23 pp.



Theobald Smith

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVII—TWELFTH MEMOIR

BIOGRAPHICAL MEMOIR

OF

THEOBALD SMITH

1859-1934

BY

HANS ZINSSER

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1936

THEOBALD SMITH

1859–1934

BY HANS ZINSSER

One is constrained to write simply of Theobald Smith, for he was a simple person, simple in the sense in which one uses this word in connection with Pasteur and Claude Bernard, with Huxley and Haeckel; or in which one applies it to some American contemporaries of Smith himself who have carried the great tradition of the founders of modern biology into our own generation.

It is surely not an accident that one can point to so many examples of men, who during this period, achieved great scientific distinction and, at the same time, possessed qualities of character which extended beyond their scientific preoccupations into all their other relations. The writer of these notes has, of course, lived too long among scientists to claim that one can deduce general rectitude from distinguished scientific intelligence. But among the greatest, in whose ranks posterity will give Theobald Smith an unchallenged place—there are so many whose lives were characterized by qualities of unpretentious probity, by almost childlike guilelessness, and by an instinctive integrity of thought and action that one is tempted to attribute their achievements in discovery in part, at least, to these qualities. One saw them in Ehrlich and in Metchnikoff as one sees them in Bordet, Nicolle, C. J. Martin, and F. Gowland Hopkins. For it is true, surely, that without complete intellectual integrity of purpose no problem can be truly resolved. And, for them, such a manner of approach does not represent an act of mental discipline but is the instinctive expression of personality.

Theobald Smith was born in Albany, New York, on July 31st, 1859. His father was a German who came to this country shortly before 1850; and though we have no exact record, the time of immigration and the quality of the stock indicate that he was one of those of 1848 who saw in the new land, the

promise of freedom of thought and action which brought so many of that temper to America during those years. The family was native of the region near Limburg on the Lahn. The name was Schmidt, but almost immediately changed to Smith. The mother was Theresa Kexel, some of whose family are still living in Frankfurt am Main.

The new country was perhaps disappointing in material opportunities, for Philip Smith, the father, kept a small tailoring shop in Albany, but the quality of the man was apparently that of so many of his immigrant contemporaries with whom material circumstances were utterly unrelated to dignity, pride, and intellectual aspirations. The household seems to have been one in which there prevailed that atmosphere of affectionate contentment and intelligent simplicity which one associates with Germany before 1870, for which there is an untranslatable German word, "Biederkeit." There was music in the house—Theresa Kexel's people had been school teachers and musicians, and the boy, Theobald, had from his mother the taste and technical instruction which, later, gave him his most comforting relaxation in his hours at the piano. In a practical way his music was a great help, since it made it possible for him to earn a part of his livelihood while a student at Cornell by playing the organ for service in the chapel.

His early education was in the public schools of Albany which at that time must have been unusually good. The boy seems to have been a prodigious worker and it appears likely, also, to one familiar with the type represented by his parents, that he was vigorously encouraged to intellectual effort at home. The habits of work formed at this time persisted throughout his life. The writer once, some years ago, remarked to one of Doctor Smith's assistants that the professor must be an extraordinarily hard worker to cover so much ground. The answer was: "Well, Doctor Smith occasionally takes a Sunday afternoon off." His early inclinations seemed to favor mathematics, an interest which—like the piano—became one of the relaxations of his leisure moments. On graduation from the high school at eighteen, he won a State Scholarship to Cornell by competitive examination. Professor Gage, who was one of his

teachers at this time tells us that his career as a scholar was so brilliant, that in spite of the necessity of earning money to pay his way, he was encouraged to specialize in almost every subject in which he showed interest; in consequence he found it extremely difficult to decide which course to follow as a profession.

His first plan after graduation was to teach school. Medicine became second choice when he failed to get a job. One wonders what would have happened if some condescending high school principal had, at this time, offered him a thousand dollars a year to teach algebra. It is more than likely that an astronomer or physicist would now be writing this memoir. When he did finally choose to enter the Albany Medical School, some of the mathematicians at Cornell said that they "had a grudge against the biologists for spoiling a perfectly good mathematician."

He entered the Albany Medical School in 1881 and, during the course—two years in those days—spent one spring semester in the biological laboratory at Johns Hopkins. He was fortunate in his masters. At Cornell he had been associated with Gage and Wilder, at Hopkins he came under the influence of Newell Martin and Brooks. Laboratory life was still in the tradition of close contact between teacher and student, and the activities of teaching and research were still—as they always should be—so closely allied that intellectual relations struck root deeply. That it is convention and not material circumstances that has threatened to change this is exemplified by the continued influence of men like Edmund B. Wilson, Morton Wheeler and some others, now all too rare. At any rate, the men with whom Theobald Smith worked at this period of his career had a powerful influence in bringing out his latent talents and ripening his inclinations;—and they must have gathered much comfort from him. Realizing, when he graduated as a Doctor of Medicine in 1883, that the two years of study had not prepared him for the practice of medicine and having no taste for an apprenticeship in country practice, Smith returned to Cornell for graduate study. He was engaged in his early studies on histological technique when Dr. Daniel E. Salmon, chief of the Bureau of Animal Industry at Washington, con-

fronted with serious economic problems of disease in domestic animals, appealed to Doctor Gage for a young man adequately trained to help him with his difficult tasks. In 1884, at the age of 25, Smith went to Washington. He knew no bacteriology and little pathology. His training in the biology of the Darwin-Huxley tradition had been as good as this country could furnish at that time. But, for the specific work in which he was, almost immediately, to become eminent, he had had no teaching, no books and no journals. He undertook to teach himself and, as Doctor Flexner has said, the textbooks from which he learned his profession were the papers of Pasteur and of Koch. This was the meager training of one who—as Dr. Preston Keyes has justly said—will be increasingly regarded as "the most notable figure in American medicine of his period." Meager it was from the modern point of view. One wonders, however, whether we could not draw a lesson from it in regard to the value of reading the great classics of experimental discovery, an exercise not often now practiced in our courses.

Theobald Smith's productive career began while he was still a medical student. Two papers on pathological technique, published in collaboration with his teacher and life-long friend, Professor Simon Henry Gage of Cornell, appeared in 1883 and 1884 respectively. His last important publication, his book on Parasitism and Disease, appeared in 1934, the year of his death. The span of his activity, therefore, covers almost the entire course of modern bacteriology—from shortly after its beginnings to the present day. Koch's work on anthrax was done in 1876 and 1877; and Pasteur's studies on the same subject, in which he had hesitated to embark because of his "utter ignorance of medicine," fall into the same period. Methods of pure-culture isolation and of staining came between 1881 and 1885. The tubercle bacillus was discovered in 1882. Pasteur's first fundamental studies on immunization, culminating in the historic anthrax experiment at Pouilly-le-Fort, were carried out in 1882. In this the "Golden Age, the Romantic Age of discovery in medicine," to use Dr. Welch's expression, Theobald Smith began his work. His contemporaries of those years, in the breaking of furrows through the rich soil of a new sci-

ence, were the men whom we of today regard as of another generation. And yet, of him, one of the pioneers—companion in early adventure of Duclaux, Chamberland, Roux, Metchnikoff, Pfeiffer, Loeffler, Ehrlich—we think of as no less our own contemporary, as young as the youngest of us into his 75th year, yielding nothing in elasticity of mind, in receptiveness to change and new conception to men twenty and more years his juniors. Of that great group only Bordet and Nicolle[1] are left, ten or more years younger than he but, with him, examples of that indestructible youthfulness of spirit that seems to be an attribute of the greatest only. A man grows old, at whatever age, when he loses his capacity to change his views with new information. Never throughout his long career did it occur to anyone of his professional colleagues, old or young, that Theobald Smith "was through," that he had exhausted his originality or his capacity for discovery. Of few men can this be said into three score and ten.

The qualities of mind which made this extraordinarily prolonged productivity possible can, to some extent, be discerned from some of his own writings. In 1933 in a letter to Professor Krumbhaar, Dr. Smith elaborated upon remarks he had made at a dinner in his honor in Philadelphia. He was then 74 years old. Among other things, he said; "To those who have the urge to do research and who are prepared to give up most things in life eagerly pursued by the man in the street, discovery should come as an adventure rather than as the result of a logical process of thought. Sharp prolonged thinking is necessary that we may keep on the chosen road, but it does not necessarily lead to discovery. The investigator must be ready and on the spot when the light comes from whatever direction." And again—"We must not be discouraged if the products of our labor are not read or even known to exist. The joy of research must be found in the doing since every other harvest is uncertain. . . ." In the same letter he, whose observations form strong bulwarks of a number of fruitful theories, has this to say:—"In general a fact is worth more than theories in the

[1] Charles Nicolle died shortly after this memoir was written.

long run. The theory stimulates, but the fact remains and becomes fertile. The fertility of a discovery is perhaps the surest measure of its survival value." He combined, with the capacity for infinite pains in detail, a philosophical power of generalization. But he never generalized on any problem until the ascertainable facts bearing upon it had been marshalled in an orderly conception. He had the sane wisdom of carrying a problem as far as he saw prospects of solving it, then leaving it to lie fallow until new light made progress possible. "I have always taken up the problems that lay spread before me," he said. "My interest in a problem usually lagged when certain results could be closely formulated or practically applied. To continue to analyze still further every link of the established chain either failed to hold my interest or was made difficult or impossible from causes lying outside the problem."

It may be remarked, in passing, that in these quotations, as well as in much that Theobald Smith wrote and said there is an evidence of a sense of style and a sensitiveness in the choice of word and phrase which reveal the quality of his mind—perhaps in another sense—but no less than do his scientific achievements.

To give a detailed account of Theobald Smith's work is quite impossible in a short memoir. There is before us an incomplete list of his published investigations—some 240 titles—exclusive of addresses and government reports. We must limit ourselves to brief discussions of those major achievements which have given him his permanent place among the founders of our science.

In 1884, a young man of 25, one year out of the Albany Medical School, he became an assistant in the Bureau of Animal Industry at Washington. Unable, for lack of means, to spend a year or two—as he would have liked to, in Europe, under the eyes of the masters, Pasteur, Koch, and Virchow—he undertook to teach himself; and in the year of his first professional appointment introduced the methods of Koch to American laboratories. This was the beginning of his interest in tuberculosis, the brilliant culmination of which will be discussed below.

His early papers dating from 1885 to 1890—about 28 in number—treated of a variety of subjects, obviously suggested

by the necessity for the development of technique and by the problems of a practical nature referred to the Bureau in which he was serving. He studied and extended Koch's technique for the isolation and cultivation of tubercle bacilli and introduced improvements in the methods of isolating pure cultures. He, even then, recognized the variability of pathogenic organisms and called attention to the dangers of relying too rigidly upon the study of old laboratory cultures. Although at that time and long afterward there was no knowledge of bacterial dissociation as we now understand it, Theobald Smith throughout his investigative career, as we know from occasional remarks and from the advice he gave others, insisted on the study of fresh isolations for accurate information. Just what it was that changed he could not determine, but accumulated experience told him that adaptation to saprophytic habits modified organisms so that they no longer represented the exact biological agent parasitic in the animal body. This was perhaps an outgrowth of his attitude toward the study of infectious disease which to him was always a specific example of parasitism, to be studied along the broadest biological principles.

If one reads carefully his papers on bacterial variability, together with his observations on the adaptation of pathogenic bacteria to different species of animals, one gains the impression that except for the chemical definition of antigenic structure he had formulated and applied the essential principles of what we now call dissociation. The same trend of thought appears in his later views on the intermediate forms of tubercle bacilli ranging between the bovine and the human type.

It is more than likely that this early preoccupation with bacterial variability, which later extended to analogous observations in respect to serologic reactions, initiated the conceptions formulated in 1903, in his paper with Reagh. In this study it was shown that the flagella of motile bacteria may possess antigenic constituents other than and separable from those contained in the bacterial bodies, a discovery which, today, by the work of Felix and others, has become of great importance, both theoretical and practical.

Into this period also falls his interest in the bacteriology of

drinking water, as an outcome of which he devised and introduced the fermentation tube, a small thing in itself and merely an ingenious adaptation to bacteriological purposes of a piece of apparatus long in use for sugar analysis in biochemical laboratories. But the purposes for which Smith employed this simple device exerted an immediate and far-reaching influence on bacteriology since it furnished an easy method for the determination of gas production by bacteria, for preliminary gas analysis, for the study of reducing powers and for the cultivation of anaerobic organisms in fluid media.

Work with his fermentation tubes led him almost directly to the discovery of one of the most useful and, today, indispensable methods for bacterial differentiation. In 1889 he reported the fact that on glucose media the typhoid bacillus produced no gas, whereas the bacilli of the colon group caused copious gas formation. Later, in 1892, he discovered, with the same method, the differential value of lactose and saccharose in the classification of the bacteria of this group, establishing a simple procedure which is still basic to many of our most useful methods for differential isolation, for stool and water analysis and for the recognition of forms in the difficult field of systematic bacteriology. The extension of this method to the investigation of practically all other groups, engaged the attention of many bacteriologists all over the world for half a generation after the publication of this short paper.

Much of Doctor Smith's bacteriological skill was developed, during this period, by his studies of the diseases of swine. Among the many maladies by which these animals are afflicted there are two which were often confused—one, Swine plague (Schweine-seuche), the other, Hog cholera (Schweine-pest). Smith clearly established the separate existence of the two diseases in the United States (1891), confirmed the presence, in the former, of the bacillus suisepticus (one of the so-called pasteurella, a non-motile organism discovered by Kitt) and described, in the second disease, a motile bacillus of the paratyphoid B group now known as the Hog cholera bacillus. Smith was quite naturally led astray in these studies, since nothing whatever was known at that time about the ultra-microscopic agents, one of which is concerned in Hog cholera. He, however, was the

first to observe the frequent association of a particular organism with a given virus infection, a phenomenon not uncommon and not yet understood or accounted for.

His interest in the disease of swine was fortunate from another point of view. It led him into the study of methods of immunization and, with Salmon, he published two papers, one in 1886, the other in 1887, both carried out with the Hog cholera bacillus, which established the possibility of actively immunizing animals with the products of bacteria in liquid culture and with the dead bodies of organisms killed at 56° C. This was an observation of major importance which, extended by Pfeiffer and others, has given us most of our present methods of active immunization in man.

In surveying this early and, in point of volume per year, most productive period of Theobald Smith's activity, the fact which is most impressive is his almost uncanny instinct for a problem. His work was scattered over a considerable number of more or less disconnected subjects. He was feeling his way into his subject, picking up threads here and there as they appeared in the pattern of his daily work. Each one he unravelled in turn up to a point at which it led either to the establishment of a principle, the accomplishment of a useful result, or the devising of a tool which others could reliably employ. Then he dropped it and started in another direction. It may well be that he did a great many things, during these years, which ended in blind roads, but there is little evidence of this in his publications or in anything one can learn about him. Study of this period reveals practically no lost motion. Moreover, the papers themselves are written with a classic simplicity, the unadorned recording of exact observation presented with critical restraint of conclusion, in other words, with a scientific honesty of expression which was more characteristic of that period than of our own; for one finds the same thing in the publications of Pasteur, Koch, Behring and most of the early discoverers. There was, as yet, no haste or competitive spirit and public interest had not yet begun to throw its disturbing spotlight on the scientist.

Of the crowning achievement of this early period we have

yet to speak—the work which demonstrated once and for always his extraordinary qualities as an investigator, and which alone, if he had never done anything else, would have given him a prominent place in the history of our science. These were his studies on Texas Cattle Fever (Tick Fever, Southern Cattle Fever, etc.). There has been some confusion in regard to the exact part which Smith had in them and it may be well, therefore, to discuss them at some length.

In doing so, we take much of our information from the article on Smith as a Parasitologist, recently (1935) published by M. C. Hall. When Smith, in association with Kilborne, first approached the problem experimentally (1889), there was already some information about this disease and interest in it was stimulated by its great economic importance.

There had been, for a long time, an impression among cattle ranchers, vague but persistent, that ticks were in some manner related to the infection. In 1885, the geographical distribution of the disease had been approximately established by Salmon and its northern limits defined. In 1889, Curtice, the entomologist of the Bureau of Animal Industry (4th and 5th Annual Reports, Bureau Animal Industry, p. 436) spoke of an experiment carried out in the Chicago Stockyards, in which five cows were placed into a pen in which Texas cows had been held, with the result that four of them died of the cattle fever. This experiment had been suggested by the "oft repeated experiment of allowing native cattle to live on the trail of Texas cattle." A similar experiment was reported in the same year by Kilborne but, in this attempt, northern cattle were mixed, in one pen, with southern cattle rendered free of ticks—while in another pen the ticks were left on the infected animals. The result was no infection in the former, death of the animals in the latter. Again, in the same year, Smith, undoubtedly working in close association with his colleagues, described (Medical News, Philadelphia) the little bodies in the red cells of infected cattle which he later (1891) recognized as protozoa and eventually named Piroplasma Bigeminum. In announcing this discovery, Smith with the fairness and generosity of character to which "priority" squabbles were abhorent suggests that these

bodies were probably identical with those seen by Stiles in 1869, but probably unlike those of Babes (1888) because the latter claimed to have succeeded in cultivating the organism he had observed. In the longer report of 1891 Smith, with Kilborne, reported on a more extensive and thorough series of transmission experiments in which four animals were infected by the direct application of ticks. Further, they had placed southern cattle in pens with northern stock—in some cases after the removal of ticks, while in other enclosures the ticks were left on the infected animals. Also, native cattle were kept in fields in which infected ticks had been scattered on the ground. The report which is one of the classics of medical literature, established beyond question the role of the tick as the carrier of the disease. And not the least of the achievements of these experiments was the observation that the infection could pass, in ticks from mother to offspring, a new and extraordinary phenomenon of parasitism which has found its analogy in tick infection with the Rickettsia of Spotted Fever. It is certainly not a disparagement of Smith's greatness to correct the erroneous impression created in some popular accounts which belittle the merits of his associates, by stating that these fundamental discoveries were in fact collaborations between a group of well-trained and intelligent men, rather than entirely the work of Smith alone. In doing so it is quite certain that we are stating the case in the manner in which he would have wanted it told. Moreover, from what we know of him and his experimental acumen, it seems more than likely that his was the leading spirit in this collaboration by which, for the first time, the complete cycle of transmission of disease by insects was established. It is true, of course, that as early as 1877, Manson had discovered that embryo filaria, taken up from the blood of infected men by mosquitoes, developed in the insects into the final larval stages. But Manson's studies did not show how the filaria again reached man. Though the reinfection of man by the bite of the infected mosquito was indeed suggested in 1883 by an anonymous reviewer of Manson's work (see Manson-Barr, Life of Sir Patrick Manson, p. 58), the actual fact was not established until 1899 by Thomas Bancroft, some time after Ross' demonstration of the

mosquito origin of human malarial infection. The investigations of Smith and his collaborators were, therefore, the first to establish the complete cycle of transmission by arthropod vectors—a discovery which represents one of those fundamental steps forward that alter the entire course of a science, and which has practical consequences of inestimable and permanent importance. We have presented this particular work with a certain degree of emphasis upon the parts played by others than Smith and upon the significance of earlier discoveries which undoubtedly helped to shape Smith's thoughts and experiments. This we have done, not only in the interests of accuracy, but with the feeling that it would be an irreverent disservice to write about this great man's accomplishments in a manner which would have deeply displeased him and which would represent a disregard of other worthy achievements entirely foreign to his own nature.

The problem of Texas Cattle Fever had hardly been solved when Smith's attention was absorbed by another economically important disease of animals, the "black head" of turkeys. This condition was killing a large number of the birds, especially in Rhode Island, and Smith began his work at the Experiment Station in Kingston, Rhode Island. After determining, by a large number of autopsies, that he was dealing with an infectious disease, Smith convinced himself that the cause of the condition was an amoeboid protozoan which accumulated in lesions localized largely in the mucosa and the submucosa of the large intestine. In his first paper on black-head (1895) he described the disease and the parasite to which he gave the name, *"amoeba meleagridis"* (later reclassified *Histomonas meleagridis* by Tyzzer). Maurice Hall says of this paper that "This work alone would have ensured Smith a permanent and high place" in connection with the disease. It, however, left the study of transmission incomplete. And with characteristic persistence Smith went back to the problem many years later. In 1917 (with Graybill) he found that the simple feeding of feces from infected birds would not produce the disease in susceptible turkeys; it was necessary to feed, at the same time, embryo forms of a nematode (Heterakis gallinae). Graybill and Smith, at this time, considered the *Heterakis papillosa* as a

preliminary agent which served to lower the resistance of the turkeys to invasion by the protozoan. Their observation of the constant association of the worm with the disease, however, had consequences of far greater biological significance in that it enabled Tyzzer and Fabyan, in 1922, to demonstrate the actual carrying of the protozoan in the infected embryos of the nematode—an observation unique in biology representing an entirely new cycle of parasitism.

In 1895, Smith accepted the invitation of Doctor Walcott of the Department of Public Health of Massachusetts and of President Eliot of Harvard to come to Boston. He took over the directorship of the State Antitoxin Laboratory, and, in 1896 became, at the same time, professor of Comparative Pathology at Harvard. During the Boston period (1895 to 1915) Smith again permitted himself to roam widely, for he published, among other things, on the control of water supplies, on sewage disposal, on typhoid transmission by milk, on the cultivation of anaerobes, on the reducing action and indol formation by bacteria, on the adaptation of bacteria to different species of animals, on the distribution of mosquitoes in New England, and on a host of other subjects which would have exhausted the energy and made the reputation of a lesser man, but which, to him, were the minor by-products of a vitality and enthusiasm that seemed to have no saturation point. His major activities of this period were his studies on diphtheria and those on tuberculosis.

His duties at the Massachusetts State Laboratory included, among other things, supervision of the production of smallpox vaccine and of diphtheria and tetanus antitoxins. Again, in the logical development of his interest in a new subject, his first attention was to matters of technical accuracy and standardization. It is characteristic of all his work that no problem was ever directly approached until methods had been carefully adjusted and accurate technical procedures devised. The percentage of inevitable experimental error, was thus always interpolated in any deductions he permitted himself to make. Thus, his first papers on diphtheria treated of conditions of cultivation and of the constituents which favored the production of

strong toxins. Later he made similar studies on tetanus. Next he occupied himself with problems of toxin-antitoxin standardization, and only then turned to questions of actual immunization. Here as throughout all of his work, one discerns that tranquility of progress that masters desire for haste and the meticulous assembling of detached observations which gradually accumulate, as in a condenser, into the tension of an ultimate major discovery. For the student of bacteriology there is a wealth of valuable information in the papers that lead up to his important contributions. For the investigator there is a lesson in the manner in which he approached each new undertaking with a scrupulous survey of the ground, taking nothing for granted and testing all the struts of earlier claims before he entrusted them with the weight of a new experiment. In a brief review of his achievements, it is possible to deal only with the final phases.

Two things came out of his diphtheria studies which have made medical history. One of these is the recognition, in distinct contradiction of Ehrlich's "Zell-reiz" theory, that the best way to speed up the early production of antitoxin in horses is to treat them, at first, with neutral mixtures of toxin and antitoxin. In his summary of this subject (in 1909) he introduced a new principle into the science of immunology which has had far-reaching consequences. In a paper (with Brown) published in 1910, he showed that immunity can be produced in animals by the injection of completely neutralized mixtures of toxin and antitoxin and that when, in such mixtures, there is a slight excess of toxin, enough to produce a local lesion, the subsequent immunization is enhanced far above that obtained by the injection of toxin alone. A by-product of this work was the observation of passive immunity in offspring born to actively immunized female guinea pigs. One of the last sentences in the paper of 1910 (in which he permitted himself to speculate on the probable mechanism of the observed results), is so characteristic of his manner of thinking that it seems worth quoting. "Hypotheses bring largely scaffolding for furnishing footholds in the building up of facts. We place no special value on the one here presented excepting insofar as it helps stimu-

late further investigation etc." In this case Smith's observations became not only the basis for more effective antitoxin production in horses but undoubtedly suggested to Behring the active immunization of man with toxin-antitoxin mixtures, a method later perfected by Park to the enormous benefit of American children and only now being superseded by the "anatoxin" methods of Ramon, Glenny and others. It is also quite certain that these observations called attention to the possible reversibility of antigen-antibody reactions, a conception which has so profoundly modified physico-chemical views of these phenomena.

In the course of his diphtheria studies Theobald Smith had noticed that guinea pigs which had been used for toxin-antitoxin standardization and had survived such mixtures without apparent injury, would show signs of respiratory distress and, on occasion, would die when subsequently injected with horse serum. One wonders just why such experiments were done. Undoubtedly they were controls in the course of his other work. We will never know what was in his mind when he reinjected these test animals with horse serum, for, he, himself, though the occurrence is now known as the "Theobald Smith phenomenon" never wrote a word about it. Nevertheless, he noted it and considered it—as he did every unexplained occurrence which appeared with regularity—as sufficiently important to follow up. He told Ehrlich about it in 1904. Ehrlich named it the "Theobald Smith effect" and set Otto to work on its analysis. Richets' observation of 1902 on actinocongestin had been but vaguely understood. The "Arthus" phenomenon, in rabbits, though of an importance equal to that of the guinea pig observation, was not systematically studied by investigators until much later. In the hands of Otto and of Rosenau and Anderson the "Theobald Smith phenomenon" became the cornerstone of our modern knowledge of hypersensitiveness, the foundation of that extraordinary chapter of investigation which has had so profound an effect upon all our conceptions of immunity and which opened new paths in clinical medicine. It is the only instance we can recall of any man's permanent and justly appraised distinction in connection with a phase of scientific development about which he himself never published a word.

Smith's publications on tuberculosis began with the papers of 1884 in which he introduced Koch's methods to American laboratories—(methods which he had learned and successfully applied entirely on his own initiative). In 1886 he developed a modification for the isolation of tubercle bacilli but, diverted by other problems, he did not resume the serious study of tuberculosis until 1893. At this time Koch himself seems to have had no doubt about the complete identity of the tubercle bacilli which infected man and those which caused the disease in cattle. This view was generally accepted and freely stated by the German school, in spite of the fact that Villemin (we take our citation from the scholarly article on Smith by William Bulloch) in his "Etudes sur la Tuberculose" (1868) had said: "Nous ferons remarquer qu'aucun de nos lapins (!) inoculés avec du tubercule humain, ne nous a presenté une tuberculisation aussi rapidement et complétement généralissé que celle que nous avons obtenue avec l'inoculation du tubercule de vâche." In the years 1894-1895 Smith isolated and studied a bovine culture and one from a racoon-like animal (Nasua narica) probably infected from a tuberculous man. He was struck by the great difference in virulence for cattle between these strains and noted differences in morphology and cultural behavior. In 1896, these studies were more systematically resumed in the new laboratories at the Harvard Medical School and, by 1897, he had isolated a sufficient number of pure cultures of both the human and the bovine type to take advantage of the cooperation of the Massachusetts Cattle Commission for experiments on animals on a satisfactory scale. His first publication on differences between the two types appeared in 1896. By 1898 he had definitely formulated his conception of these differences in a manner so soundly founded upon precise observation that no further doubt was possible. He differentiated his strains not only by the variations in virulence of those of bovine origin for cattle, rabbits, and guinea pigs, but described differences of morphology and of growth on glycerine media. In 1905, he added the so-called "Smith acid curve" on glycerine broth. These observations, rapidly confirmed by Vagedes, Dinwiddie, Ravenel and eventually by Koch himself, apart from

their important biological value, introduced new conceptions in regard to the transmission of tuberculosis by milk, and influenced practical methods of control. It is of incidental interest that Smith, himself, even at this time, realized that the differentiation he had discovered was not an absolute one in all cases. He says, for instance (1902), "We may now maintain without fear of contradiction that the bovine bacillus presents certain traits which serve to distinguish it *from the great majority* of bacilli isolated from the human subject. These traits or characters are not the exclusive property of the bovine bacillus as contrasted with those from human sources. I am merely emphasizing the constancy of such characters and not their peculiarity." He called attention to the variability of individual strains of human origin and steadfastly refused to follow speculatively beyond the boundaries set by precise experimental information, rejecting, in turn, the extreme view of Koch, that bovine bacilli do not pass to the human subject and the subsequently formulated opposite extreme of Behring, that most human infections are acquired in childhood from infected milk. He regarded all such speculation as premature, advocated continued efforts to isolate and classify tubercle bacilli from larger numbers of human cases of all clinical types, saying in this connection, at a time when his greatest contemporaries were taking sides: "Whatever deductions and inferences we make from time to time, must ultimately derive their authority from actually observed fact. The larger the number of cultures isolated and studied according to a uniform scheme, the more reliable our inferences and conclusions." On a material necessarily limited, since this type of work takes time, he concluded that bovine infection of man occurs but does not represent the most frequent manner of human infection—a point of view which all subsequent work has confirmed. There have been no important modifications in the conception of this summary since he wrote it in 1902.

Considering the obvious possibility that the differences between the two major types might be consequences of an adaptation of parasite to special host, a matter which always interested him beyond all other subjects, he carried out experiments, lasting

more than two years, on serial animal passages of both human and bovine strains, obtaining inconclusive results and saying so. It was his habit, when he reached a blind end through which he could see no rational experimental escape, to drop the subject and for a time to turn to something else. The problems which he left unsolved in regard to bovine and human tuberculosis stand, at the present day, just about where he left them.

In 1901, the newly founded Rockefeller Institute for Medical Research was ready to appoint a director. Theobald Smith was the natural candidate and Doctor Welch urged him to accept the responsibility. Smith, though tempted, knew that this was not the work for him at this time. He "anticipated much good from this new institution" but he was suspicious of organized research and said (a remark from a letter quoted by Professor Simon H. Gage) ". . . you and I know that research cannot be forced very much. There is always the danger of too much foliage and too little fruit." Individualist by inheritance, inclined by character and training to scientific still-hunting on his own, seeking cooperation only when it was indispensable for a specific objective, he knew that he was not the man at that time to undertake the organization of such an institution. Although the subsequent history of the Institute has shown that his apprehensions were unjustified and fruit has appeared plentifully among the foliage, he was probably wise and a better judge of himself than others in refusing when he did. He took administrative responsibilities too seriously, worried and was made unhappy by them. He was, surely, however, a tower of strength to the director subsequently appointed, and was far more useful as a member of the board of scientific directors and, after the death of Doctor Welch, as president of this board. Later, in 1914, he did accept the directorship of the branch of the Rockefeller Institute established at Princeton, for the investigation of the diseases of animals. Harvard did not like to let him go and the writer has often wondered why Doctor Smith who had refused in 1901, was willing to undertake such a responsibility in 1914. A remark made by Doctor Flexner at the farewell dinner in Boston and quoted by Doctor Gage throws some light on this question. Doctor Flexner, speaking of the discussions which

had led up to the formation of the new laboratory, said: "It was Doctor Smith's vision of such an independent department, itself conceived on broad lines, that made it attractive first to his colleagues in the directorate and then to the founder who was to give it his financial support. This support, you may be interested to know, came promptly as soon as it was known that Doctor Smith would undertake the direction of the new work himself." In the jargon of our day, Doctor Smith was "on the spot." He had, by this time learned, moreover, that an Institute need not necessarily be an organization for regimented volley firing, but that, as in universities, well-selected workers could be left to themselves. Opportunities for work could be rendered as convenient as possible and cooperation made available when required without being organized like a battalion in the field. He had begun to realize, as many of the rest of us did, that institutes of research could be like university laboratories without the teaching obligations, and to forsee what is now happening, that university laboratories to be effective must approach somewhat the organization of the research institute. At any rate, he undertook the new work without the slightest intention or fear of relaxing his own experimental efforts. Whether he was a good "director" or not no one will ever know from the expressed opinions of others. If he had his faults they were so smothered by the distinction of his mind and the affection aroused by the simple sincerity of his character that they carry no weight. We pose the question only because he seemed to us the extreme antithesis of what is known as an "administrator." Yet, even though his administration may have lacked some of the characteristics most approved of by those who believe in such things, the fact remains that when he relinquished his directorship in his 70th year (1929) his institute was doing distinguished work and he had gathered about him a group of younger associates, some of whom are doing brilliant work and many of whom caught fire on the sparks from his anvil. Whether another with his characteristics could have done the same thing is doubtful. To work with or near Theobald Smith was an inducement that was worth more than large salaries; and there is no one among the younger bacteriologists in this

country who, if he possesses common sense enough to be a good bacteriologist, does not wish he had been, at one time or another, a pupil of this great and lovable man.

The manner in which Theobald Smith approached his new work is above all revealed by the fact that his own contributions continued in uninterrupted series. We have on our list between 1915—the year in which, at the age of 56, he assumed the new directorship—and 1934, the year of his death, sixty-five papers, eight addresses, and a book of almost 200 pages on Parasitism. Some of these papers are continuations of his tuberculosis and diphtheria studies and, in others, he continued his work on "black head" in turkeys, of which we have spoken in another place. A few deal with parasitism in its broader biological significance, leading up to a final summary in his book. One paper (with Brown) brought a considerable degree of orderliness to the confused streptococcus problem. The major part of his work during his latter years, however, concerned itself with infections of animals in which he had the opportunity to follow his favorite line of thought, that of the factors which determined adaptation changes in closely related bacterial species. In this field he occupied himself with spontaneous paratyphoid infections in rodents and with the Brucella. As early as 1912 he had become interested in infectious abortion of cattle, had—"accidentally" as he called it—observed and described the lesions produced in guinea pigs by the bacillus of Bang and "was reminded" of similar observations made in a guinea pig infected with centrifugalized milk seventeen years previously, thus calling attention to milk as a vector of the infection. It is important as a side-light on his methods of work to quote a footnote from his 1912 article. "Since that time (the time of his first observation of the milk infection, 1894) I constantly looked for repetition of these lesions but never found them. Now, after seventeen years, I may consider them explained. At that time I suspected accidental contamination of the milk." That sort of thing goes far toward letting us understand the secret of his extraordinary productiveness. In further studies of the organisms of this group he described the first appearance of the porcine variety of the disease in the eastern United States,

devised the partial CO_2 atmosphere method of cultivating the organisms, observed the location of the bacilli in the bovine foetal membranes, defined the relationship of the bovine and porcine types to those isolated from man and suggested the direct contamination of man from swine. Incidentally he described another possible cause of bovine abortion—a spirillum which he named Vibrio Fetus.

Overlapping his abortus studies were his investigations of another bovine disease, "scours" a diarrhoeal condition which accounted for a high "infant mortality" among calves. On this subject alone he published some ten papers. As usual, he familiarized himself with the clinical characteristics and the pathology of the disease. He then discovered the association of the malady with failure of maternal feeding during the first week of life. This suggested colostrum and led to a field experiment in which ten calves receiving colostrum survived and eight out of twelve, deprived of colostrum, died. One was killed when nearly dead. In cultures from these animals he obtained bacillus coli. He found that early death was due to a flooding of the bloodstream and organs with the colon bacillus and that, in the few that survived, lameness and arthritis were due to persistence of the infection in the joints. Suspecting that the action of the colostrum might be attributable to its immunological properties he successfully substituted cow serum for colostrum. Following this, he determined that the blood of new-born calves contained no antibodies though their dams might have blood titers as high as 1 to 2,000. Antibodies in cattle, therefore, do not pass from mother to offspring through the placenta. On the other hand, when fed by mouth in the form of cow's serum antibody feedings rapidly appeared in the circulation of the calves. Colostrum thus could be regarded as a "most efficient transporting agent of antibodies" from mother cow to calf. The problem of "scours" prevention had been transformed from the almost hopeless efforts of isolation and the protection of food to a relatively simple immunological one for which there were several solutions—the easiest one that of leaving the calf with the cow during the early weeks after birth.

The account of Doctor Smith's work which we have given represents little more than an outline of those major accomplishments on which his permanent place among great discoverers in biology will rest. It has been necessary to neglect a great number of papers and notes which represent marginal observations and transitional studies carried on at times when intervals between the larger undertakings gave him leisure to follow incidental ideas. Among these, for him, minor preoccupations, there is enough material and thought to have made the reputation and to have satisfied the ambitions of most men of lesser intellectual vitality. Many of these investigations deal with matters of technique. Others were observations on diseases of animals—usually interesting him as illustrations of the extraordinary flexibility of parasitic adaptation. These papers deal with rabbit septicaemia and coccidiosis, with the spirillosis of hogs, with bacterial infections of poultry, the coccidiosis of sparrows, the sporadic pneumonia of cattle; with actinomycosis and the mycosis of the bovine foetal membranes; with intestinal sporozoa, with the encephalocytozoa of rabbits and with milk-borne streptococcus diseases. A study of a non-toxic diphtheria bacilli (1914) anticipated our present information on the dissociation phenomena of these organisms.

In the field of the general biology of microorganisms he published on the relationship between parasitic and saprophytic bacteria; on the origin and source of pathogenic forms; on temporary and permanent modifications of physiological characters in mixed cultures; on the adaptation of parasites to different species of animals; on parasitism as a factor in disease, and on the passing of infections from one generation to another.

Correlating his bacteriologic studies with problems of public health he developed a reliable technique for bacteriological water analysis, described the "presumptive test" for colon bacilli, and contributed papers on channels of food infection, sewage disposal on farms, sources and prophylaxis of malaria in temperate climates, anopheles distribution in New England, the horsefly as a disseminator of disease, and the prevention of tuberculosis. Taking an active part in the educational and administrative problems of his period he outlined the reorganization of the Harvard

Veterinary School and formulated plans for the organization of public health laboratories. He defined the place of research in university medical schools and his paper on scholarship in medicine was, at the time of its publication, a wholesome differentiation between trade and profession. He pleaded, one of the first to do so, for a closer relationship between medicine and public health and pointed out the economic aspects of the study of comparative pathology.

We begin by marveling at the long duration of his active career. We end by wondering how, in a short (to him, surely, a very short) fifty-one years, he could have accomplished the enormous volume of work that stands to his credit. We study his amazing productiveness and are still more astonished by the fact that, great as it is, it contains almost no errors. In all but a very few of his papers, the facts observed remain today as they stood when he recorded them and the deductions based on them are sound in that he never permitted himself to stray speculatively beyond his lines of communication with facts. Moreover, when he did allow himself to speculate—as in his studies on bacterial variation, flagellar agglutination, bovine and human tuberculosis and in his many papers on parasitism, he anticipated, in principle, a number of things that later discoveries established in fact; proof that he possessed, to a high degree, that quality of scientific imagination which Whitehead has defined as "speculative reason" and which is probably the determining attribute which differentiates men who are truly great from those who are merely able.

It is usually futile but always interesting to explore the intellectual pattern which made possible great accomplishments. We have already spoken of the quality of simple integrity which was as much a part of Theobald Smith as his physical build. This, coupled as it was in Pasteur, Claude Bernard and others of his kind, with extraordinary intelligence, infinite patience and technical accuracy, goes far to account for his success. There were other contributing factors, however, which were peculiar to him. His investigations were never academic in the sense that they took off from theoretical preconceptions. As he said himself, he took his problems as they were spread out before him by

questions that were crying to be solved. There is perhaps a lesson in the fact that until the last stage of his career he was never a pure research worker but held positions in which the currents of his activities were to some extent directed by specific duties which had to be performed and from which his problems took origin. In his approach there was deliberate preliminary study of conditions and of technical methods. His choice of methods was always the simplest, determined by the shortest path to his objective. It is, incidentally, strange that, although an accomplished mathematician (Professor Wheeler has told us that he did problems of calculus for amusement in the same way that he played the piano) there is no instance in all his work in which he employed mathematical methods. This is probably due to the fact that he adapted his procedures with the greatest economy to the purposes he was pursuing and he recognized that the particular materials he worked with were not ready for mathematical treatment. He possessed an extraordinary sense for the essential and was not easily diverted by side-issues. He wasted no time in trying to break through when he came to the end of methods for further precise observation but dropped problems in which he could see no immediate logical paths of approach, postponing them until new methods or ideas turned up. But he kept them in mind with an extraordinary memory for detail and rarely failed to resume work once begun when obstacles had been cleared away by new discovery or when chance revealed new methods of attack.

In occasional discussions with him, we learned to our profit—as undoubtedly many others did—that, in approaching a new problem of infection, however detailed the immediate objective of his experiments, he never failed to bear in mind the disease itself as a complete entity. There has been a tendency, with the increased availability of precise methods of the fundamental sciences, for bacteriological investigation to segregate isolated fractions of a problem for analysis with frequent neglect of the correlation of results with the problem as a whole. This is inevitable under circumstances, progressively more common, where the biologist cannot be trained in the more difficult methods of chemistry and physics and the chemist or physicist does

not possess the medical or epidemiological knowledge necessary for the assembly of the isolated facts into a coordinated conception. Theobald Smith exemplified what, to us, appears an important principle, that the biologist who approaches a problem of infectious disease cannot afford to confine his attention to the bacteriological and immunological details which are the immediate objectives of his observations but must familiarize himself with the clinical, pathological and epidemiological conditions as well—a task which is entirely feasible for the well-trained bacteriologist though he may be entirely incompetent to control those methods of chemistry and physics the results of which he must interpolate by intelligent cooperation with the chemist. This is more or less what Theobald Smith did in his work; and a few paragraphs from the introduction to his treatise on parasitology appear to us to define the relation of the experimental method in biological study to other approaches more clearly than this has been done since the publication of Claude Bernard's book.

"The great development of experimental science in the study of the phenomena of life has thrown somewhat into the shadow the older comparative method. The latter looks at things in nature, describes and compares them, and deduces from such comparisons certain underlying concepts. The experimental method takes the same phenomenon and tries to check or limit all but one of the activities entering into it so that this one activity can be observed, recorded, measured, and weighed. *Obviously the phenomenon has not been entirely elucidated by this process. Even after we review all conceivable manifestations of the natural phenomenon in this way, there still remains the problem of formulating the properties of the whole on the basis of the interacting activities of its parts.* And so it happens that if we apprehend or appropriate an idea that is based on definite experimental proof we are apt to let it overshadow other perhaps more inclusive ideas which have not yet been demonstrated or which from the nature of the case cannot be subjected to rigid demonstration. Both methods have their special advantages and disadvantages. The whole must be supplemented by some means for looking beneath the surface and

observing the mechanism that controls its activities. *The experimental method must not let too many machines get between it and the whole and must find some way of putting the fragment surgically removed for experimental purposes back into the whole.* The comparative method is frequently in position to restrain the generalizations deduced from experimental procedures and to keep the experimenter from steering away from the goal, which is an understanding of the totality.

"The subject to be presented deals with living things and the observational, comparative method shares equally with the experimental, analytic method the burden of trying to pry into the behavior of two organisms in conflict. Living things, we are learning day by day, have unlimited capacity for variation and adaptation. They are primarily individualistic and in our experiments can be kept unchanged only by strictest adherence to uniform conditions, not only of environment, but of descent. Watching the evolution of our individual fields of work we can plainly see past errors in the acceptance of uniformity where there has been none to speak of.

"In the study of disease due to microbic and higher parasites we can see quite distinctly two lines of development, the theoretical trying to dig beneath the observations towards more fundamental concepts embodied in physics and chemistry, and the medical or practical striving towards the surface to bring research into use."

Theobald Smith's preeminent contribution to the progress of bacteriology in general is obvious from the summary of his work. The influence which he exerted on the development of our science in our own country was greater than that of any other individual. Never, except for a short period, a teacher in the organization of formal courses, he, nevertheless, by his writings, through the men he trained in his laboratories and by the unvarying kindness with which he gave advice and encouragement became, in a sense, the most important teacher we possessed. He showed interest in any problem intelligently presented to him and his advice was never given in a patronizing manner, always as from one scholar to another, however young and inexperienced the applicant provided he was clear-headed and

honest and the problem one that deserved attention. He had, moreover, the quality of looking at experimental results with utterly unprejudiced eyes, examining them in complete detachment from preconceptions. He never tried to fit a set of phenomena into a theoretical pattern until he had finished with it as a thing in itself, a habit by which, in appraising the work of younger men, he often corrected premature interpretations and helped to avoid error. Even when dealing with subjects in which fundamental conceptions had been fairly well established his point of view possessed a quality of originality which stimulated thought. In 1911, when the present writer was working for a few months in a Berlin laboratory, Smith was exchange professor at that university. His lectures on immunity, delivered in excellent German, were probably unlike any other lectures ever given on this subject. They were secondarily immunity, primarily Theobald Smith—scaffoldings of accepted views became the themes for the discussion of observations drawn from his immense experimental experience. They were lectures quite disappointing to those who wanted a review of conventional trends, intensely interesting to those who had begun to develop critical insight and investigative curiosity.

Of Theobald Smith the man, of his friendships and his more intimate personal relations, Professor Simon H. Gage has warmly written. And even if a memoir of this kind were the proper place for the recording of such things; there are few who could do justice to these aspects of his life since, though kindly and possessed of a natural friendliness, there was about him an unobtrusive pride, a reserve tinged with austerity which did not invite easy intimacy.

But even without such intimacy, as one studies his life and tries to formulate a conception of the man in his wide influence, one develops an affection for him something like that which one feels after reading the lives of Pasteur or of Huxley. To the younger bacteriologists whose lives overlapped his own, Theobald Smith was a hero to be emulated and whose approval was a mark of distinction. He illustrated to them the dignity of austere devotion to scholarship and the modesty of wisdom. But always they stood a little in awe of him. He, with Welch,

were the two greatest individual influences that helped to hold the younger men working in the medical laboratories steadfast in the faith of the worthiness of honest effort. But Welch was loved instinctively for the warmth of his heart and for the urbane benevolence with which he encouraged younger men and commended them often beyond their deserts. Of Theobald Smith they thought as the dispassionate critical mind by which they were impersonally, though justly, appraised.

In following his career and studying his work a warmer current flows into one's thoughts of him. One feels that he was lonely in the restraints by which reason disciplined him. One wishes one had been more intimately his pupil. And in realizing the great debt our science owes to him, one begins with admiration and ends with affection.

BIBLIOGRAPHY OF THEOBALD SMITH

1883-1934

1883

Serial microscopic sections, (with S. H. Gage). Med. Student, 1883-84, 1, 14-16.

1884

Section flattener for dry section cutting; note 1 and 2, (with S. H. Gage). Microscope, 1884, 4, 25-26.

Diagnostic and prognostic value of the bacillus tuberculosis in the sputum of pulmonary diseases. Albany Med. Ann., 1884, 5, 193-198.

Method of demonstrating the presence of the tubercle bacillus in sputum. Albany Med. Ann., 1884, 5, 233-236.

On a new method of producing immunity from contagious diseases, (with D. E. Salmon). Proc. Biol. Soc. of Washington, 1884-86, 3, 29-33.

1885

Pathogenic bacteria and wandering cells. Albany Med. Ann., 1885, 6, 50-56.

Koch's method of isolating and cultivating bacteria as used in the laboratory of the Bureau of Animal Industry, Department of Agriculture, (with D. E. Salmon). Abst. in Am. Month. Microsc. J., 1885, 6, 81.

Remarks on fluid and gelatinous media for cultivating micro-organisms, with description of Salmon's new culture-tube and demonstrations of the process of using it. Abst. in Proc. Am. Assn. Adv. Sci., 1885, 33, 556.

1886

Notes on the biological examination of water, with a few statistics of Potomac drinking water. Abst. in Am. Month. Microsc. J., 1886, 7, 61.

A few simple methods of obtaining pure cultures of bacteria for microscopical examination. Abst. in Am. Month. Microsc. J., 1886, 7, 124, Disc. 139.

On the variability of pathogenic organisms as illustrated by the bacterium of swine-plague. Am. Month. Microsc. J., 1886, 7, 201-206.

A new chromogenous bacillus, (with D. E. Salmon). Proc. Am. Assn. Adv. Sci., 1886, **34**, 303.

Some recent investigations concerning bacteria in drinking water. Med. News, 1886, **49**, 399; publ. separately, Phila., 1886, 8 pp.

Bacterium of swine-plague, (with D. E. Salmon). Am. Month. Microsc. J., 1886, 7, 204.

Relative value of cultures in liquid and solid media in the diagnosis of bacteria. Bot. Gaz., 1886, **11**, 294-297; Med. News, 1886, **49**, 571.

1887

Parasitic bacteria and their relation to saprophytes. Am. Nat., 1887, **21**, 1-9.

Contribution to the study of the microbe of rabbit septicaemia. J. Comp. Med. and Surg., 1887, **8**, 24-37.

Experiments on the production of immunity by the hypodermic injection of sterilized cultures, (with D. E. Salmon). Abst. in Trans. Intern. Med. Cong. IX, Washington, 1887, **3**, 403.

Quantitative variations in the germ life of Potomac water during the year 1886. Am. Month. Microsc. J., 1887, **8**, 129-130; Med. News, 1887, **50**, 404.

Spirillum, Finkler and Prior, in hepatized lung tissue. Med. News, 1887, **51**, 536-538.

1888

Recent advances in the disinfection of dwellings as illustrated by the Berlin rules. N. Y. Med. J., 1888, **48**, 117-120.

Relation of drinking water to some infectious diseases. Albany Med. Ann., 1888, **9**, 297-302.

1889

Hog cholera: its history, nature and treatment, (with F. L. Kilborne). U. S. Bur. Anim. Indust., Wash., 1889, 197 pp.

Preliminary observations on the microorganism of Texas fever. Med. News, 1889, **55**, 689; Am. Pub. Health Assn. Rep., 1890, **15**, 178; Vet. J. Ann. Comp. Path., 1890, **30**, 153.

Relation of ticks to Texas cattle fever. Am. Vet., Bericht über 1889/90, **41**, 95.

Some observations on coccidia in the renal epithelium of the mouse. J. Comp. Med. and Surg., 1889, **10**, 211.
Some observations on the origin and sources of pathogenic bacteria. Sanitarian, 1889, **22**, 110-119.

1890

Das Gärungskölbchen in der Bakteriologie. Centr. Bakt., 1890, **7**, 502-506.
Einige Bemerkungen über Säure- und Alkalibildung bei Bakterien. Centr. Bakt., 1890, **8**, 389-391.
Observations on the variability of disease germs. N. Y. Med. J., 1890, **52**, 485-487.
On the influence of slight modifications of culture media on the growth of bacteria as illustrated by the glanders bacillus. J. Comp. Med. and Vet. Arch., 1890, **11**, 158.

1891

Einige Bermerkungen zu dem Aufsatze, "Eine Methode der Blutentnahme beim Menschen". Centr. Bakt., 1891, **9**, 48-49.
Investigations of infectious animal diseases. U. S. Bur. Anim. Indust., 6th/7th Rep., 1889/90, 93-110.
Kleine bakteriologische Mittheilungen. Centr. Bakt., 1891, **10**, 177-186.
On changes in the red blood-corpuscles in the pernicious anaemia of Texas cattle fever. Trans. Assn. Am. Phys., 1891, **6**, 263-277.
Special report on the cause and prevention of swine plague. U. S. Bur. Anim. Indust., 1891, 166 pp.
Washington drinking-water. Med. News, 1891, **59**, 525.
Zur Kenntnis der amerikanischen Schweineseuche. Zeit. Hyg., 1891, **10**, 480-508.
Zur Kenntnis des Hogcholerabacillus. Centr. Bakt., 1891, **9**, 253-257, 307-311, 339-343.

1892

Infectious diseases of cattle, (with D. E. Salmon). U. S. Bur. Anim. Indust., Bulletin, 1892, 271.
On pathogenic bacteria in drinking-water and the means employed for their removal, Albany Med. Ann., 1892, **13**, 129-150.
Zur Unterscheidung zwischen Typhus- und Kolonbacillen. Centr. Bakt., 1892, **11**, 367-370.
Zur Prüfung der Pasteur-Chamberland Filter, (with V. A. Moore). Centr. Bakt., 1892, **12**, 628-629.

1893

Additional observations on Texas cattle fever: on the indefinite persistence of the Texas fever parasite in the blood of southern cattle, (with F. L. Kilborne and E. C. Schroeder). U. S. Bur. Anim. Indust. Bull. 3, 1893, 67-72.
Channels of infection, with special reference to water and milk. Pop. Health Mag., 1893-94, **1**, 279-287.

Die Aetiologie der Texasfieberseuche des Rindes. Centr. Bakt., 1893, 13, 511-527.
Fermentation tube with special reference to anaerobiasis and gas production among bacteria. Wilder Quarter Century Book, Ithaca, 1893, 187-233.
Investigation of infectious disease of domesticated animals. U. S. Bur. Anim. Indust., 8th/9th Rep., 1891/92, 45-66, 96-104.
Investigation into the nature, causation and prevention of southern cattle fever, (with F. L. Kilborne). U. S. Bur. Anim. Indust., 8th/9th Rep., 1891/92, 177/304; also Bull. 1, 1893, 301 pp.
New method for determining quantitatively the pollution of water by fecal bacteria. Mass. Bd. Health, 13th Ann. Rep., 712-722.
On a pathogenic bacillus from the vagina of a mare after abortion. U. S. Bur. Anim. Indust., Bull. 3, 1893, 53-59.
Preliminary notes on a sporozoön in the intestinal villi of cattle. U. S. Bur. Anim. Indust., Bull. 3, 1893, 73-78.
Presentation Address. The Wilder Quarter Century Book, 1893, 11-15.
Some experimental observations on the presence of tubercle bacilli in the milk of tuberculous cows when the udder is not visibly diseased, (with E. C. Schroeder). U. S. Bur. Anim. Indust., Bull. 3, 1893, 60-66.
Some problems in the etiology and pathology of Texas cattle fever, and their bearing on the comparative study of protozoan diseases. Trans. Assn. Am. Phys., 1893, 8, 117-134.

1894

Additional investigations concerning infectious swine diseases, (with V. A. Moore). U. S. Bur. Anim. Indust., Bull. 6, 1894, 117 pp.
Grobe und feine Spirillen im Darme eines Schweines. Centr. Bakt., 1894, 16, 324.
The hog cholera group of bacteria, (with V. A. Moore). Centr. Bakt., 1894, 16, 231-241.
Investigations concerning bovine tuberculosis with special reference to diagnosis prevention. U. S. Bur. Anim. Indust., Bull. 7, 1894, 156 pp.
Modification temporary and permanent, of the physiological characters of bacteria in mixed cultures. Trans. Assn. Am. Phys., 1894, 9, 85-106.
Notes on the peptonising or digestive action of sterile tissues of animals. N. Y. Med. J., 1894, 60, 590-592.

1895

Antitoxic and microbicide powers of the blood serum after immunization, with special reference to diphtheria. Albany Med. Ann., 1895, 16, 175.
Investigations concerning infectious diseases among poultry, (with V. A. Moore). U. S. Bur. Anim. Indust., Bull. 8, 1895, 90 pp.

Notes on Bacillus coli communis and related forms, together with some suggestions concerning the bacteriological examination of drinking water. Am. J. Med. Sci., 1895, 110, 283-302.
On a local vascular disturbance of the foetus, probably due to the injection of tuberculin in the pregnant cow. N. Y. Med. J., 1895, 61, 233-234.
Some practical suggestions for the suppression and prevention of bovine tuberculosis. U. S. Dept. Agri. Yearbook, 1894, 317-330.
Ueber die Bedeutung des Zuckers in Kulturmedien für Bakterien. Centr. Bakt., 1895, Abt. 1, 18, 1-9.
Ueber den Nachweis des Bacillus coli communis im Wasser. Centr. Bakt., 1895, Abt. 1, 18, 494-495.
Water-borne diseases. J. New England Water Works Assn., 1895/96, 10, 203-225.

1896

Conditions which influence the appearance of toxin in cultures of the diphtheria bacillus. Trans. Assn. Am. Phys., 1896, 11, 37-61; Med. Rec., May 9, 1896.
Destruction of diphtheria toxin by other products of the diphtheria bacillus. J. Bost. Soc. Med. Sci., 1896/97, 1, No. 12, 5-8.
Injuries to cattle from swallowing pointed objects, (with C. F. Dawson). U. S. Bur. Anim. Indust., 10th/11th Rep., 1893/94, 78-81.
Production of diphtheria antitoxin. J. Assn. Eng. Soc., 1896, 16, 83-92.
Reduktionserscheinungen bei Bakterien und ihre Beziehungen zur Bakterienzelle nebst Bemerkungen über Reduktionserscheinungen in steriler Bouillon. Centr. Bakt., 1896, Abt. 1, 19, 181-187.
Sewage disposal on the farm and the protection of drinking water. U. S. Dept. Agri. Farm. Bull. 43, 1896, 20 pp.
Simple culture apparatus for anaerobic bacteria. J. Bost. Soc. Med. Sci., 1896/97, 1, No. 5, 3.
Spontaneous pseudo-tuberculosis in a guinea pig, and the bacillus causing it, (with J. R. Stewart). J. Bost. Soc. Med. Sci., 1896/97, 1, No. 16, 12.
Two varieties of the tubercle bacillus from mammals. Trans. Assn. Am. Phys., 1896, 11, 75-93; U. S. Bur. Anim. Indust., 12th/13th Rep., 1895/96, 149-161.

1897

Action of typhoid bacilli on milk and its probable relation to a second carbohydrate in that fluid. J. Bost. Soc. Med. Sci., 1897/98, 2, 236-244.
Comparative study of bovine tubercle bacilli and of human bacilli from sputum. J. Bost. Soc. Med. Sci., 1897/98, 2, 187-189; J. Exp. Med., 1898, 3, 451-511; Trans. Assn. Am. Phys., 1898, 13, 417-470.
Comparative study of the toxin production of diphtheria bacilli, (with E. L. Walker). J. Bost. Soc. Med. Sci., 1897/98, 2, 12-15; Mass. Bd. Health, Rep., 1896, 649-672.

Modification of the method for determining the production of indol by bacteria. J. Exp. Med., 1897, **2**, 543-547.
Notes on the evolution of hog cholera outbreaks. U. S. Bur. Anim. Indust., 12th/13th Rep., 1895/96, 161-166.
Notes on peculiar parasitic affections of the liver in domesticated animals. U. S. Bur. Anim. Indust., 12th/13th Rep., 1895/96, 174-179.
Notes on sporadic pneumonia in cattle; its causation and differentiation from contagious pleural pneumonia. U. S. Bur. Anim. Indust., 12th/13th Rep., 1895/96, 119-149.
One of the conditions under which discontinuous sterilization may be ineffective. J. Bost. Soc. Med. Sci., 1897/98, **2**, 133-134; J. Exp. Med., 1898, **3**, 647-650.
Swine erysipelas or mouse septicemia bacilli from an outbreak of swine disease. U. S. Bur. Anim. Indust., 12th/13th Rep., 1895/96, 166-174.
Two cases of cirrhosis of the liver. U. S. Bur. Anim. Indust., 12th/13th Rep., 1895/96, 179-183.
Ueber Fehlerquellen bei Prüfung der Gas- und Säure-Bildung bei Bakterien und deren Vermeidung. Centr. Bakt., Abt. 1, 1897, **22**, 45-49.

1898

Notes on a tubercle bacillus having a low degree of virulence. J. Bost. Soc. Med. Sci., 1898/99, **3**, 33-38.
Relation of dextrose to toxin production in bouillon cultures of the diphtheria bacillus. J. Bost. Soc. Med. Sci., 1898/99, **3**, 315-318; J. Exp. Med., 1899, **4**, 373-397.
Some devices for the cultivation of anaerobic bacteria in fluid media without the use of inert gases. J. Bost. Soc. Med. Sci., 1898/99, **3**, 340-343.
Toxin and antitoxin of tetanus. Bost. Med. and Surg. J., 1898, **138**, 292-295.
Toxin of diphtheria and its antitoxin. Bost. Med. and Surg. J., 1898, **139**, 157; Mass. Med. Soc. Med. Commun., 1898, **17**, 709.

1899

Aetiology of Texas cattle fever with special reference to recent hypotheses concerning the transmission of malaria. N. Y. Med. J., 1899, **70**, 47.
Suggestions for reorganization of the Harvard Veterinary School, (statement prepared at the request of President Eliot). Cambridge, 1899.
Thermal death point of tubercle bacilli in milk and some other fluids. J. Exp. Med., 1899, **4**, 217-233.
Ueber einen unbeweglichen Hogcholera- (Schweinepest-) Bacillus. Centr. Bakt., Abt. 1, 1899, **25**, 241-244.
Variation among pathogenic bacteria. J. Bost. Soc. Med. Sci., 1899/1900, **4**, 95-109.

Variations in pathogenic activity among tubercle bacilli. Bost. Med. and Surg. J., 1899, **140**, 31; Climate, 1899, **2**, 5.

1900

Adaptation of pathogenic bacteria to different species of animals. Bost. Med. and Surg. J., 1900, **142**, 473; Phil. Med. J. 1900, **5**, 1018.
Antitoxin unit in diphtheria. J. Bost. Soc. Med. Sci., 1900/01, **5**, 1-10.
Comparative pathology: its relation to biology and medicine. Phil. Med. J., 1900, **6**, 409.
Die Bedeutung von Varietäten bei pathogenen Bakterien. Centr. Bakt., Abt. 1, 1900, **27**, 676-677.
Notes on the occurrence of Anopheles punctipennis and A. quadrimaculatus in the Boston suburbs. J. Bost. Soc. Med. Sci., 1900/01, **5**, 321-324.
Public health laboratories. Bost. Med. and Surg. J., 1900, **143**, 491.

1901

Production of sarcosporidiosis in the mouse by feeding infected muscular tissue. J. Exp. Med., 1901, **6**, 1-21.

1902

On a coccidium (Klossiella muris, gen. et spec. nov.) parasitic in the renal epithelium of the mouse, (with H. P. Johnson). J. Exp. Med., 1902, **6**, 303-316.
Preparation of animal vaccine. Read at the Ann. Meet., Mass. Med. Soc., June 10, 1902, 16 pp.
Relation between bovine and human tuberculosis. Med. News, 1902, **80**, 342.
Vaccination and smallpox, the preparation of animal vaccine. Bost. Med. and Surg. J., 1902, **147**, 197.

1903

Agglutination affinities of related bacteria parasitic in different hosts, (with A. L. Reagh). J. Med. Research, 1903, **9**, 270-300.
Non-identity of agglutinins acting upon the flagella and upon the body of bacteria, (with A. L. Reagh). J. Med. Research, 1903/04, **10**, 89-100.
Sources favoring conditions and prophylaxis of malaria in temperate climates, with special reference to Massachusetts. Bost. Med. and Surg. J., 1903, **149**, 57, 87, 115, 139; Mass. Med. Soc. Med. Commun., 1903, **19**, 337.
Studies in mamalian tubercle bacilli. III. Description of a bovine bacillus from the human body. A culture test for distinguishing the human from the bovine type of bacilli. Trans. Assn. Am. Phys., 1903, **18**, 109-151; J. Med. Research, 1904/05, **13**, 253-300.

1904

Degrees of susceptibility to diphtheria toxin among guinea pigs; transmission from parents to offspring. J. Med. Research, 1904/05, **13**, 341-348; Abst. in Am. Med., 1905, **9**, 491.

Further observations on the transmission of sarcocystis muris by feeding. J. Med. Research, 1904/05, **13**, 429-430.

New laboratory of the Mass. State Board of Health for the preparation of diphtheria antitoxin and vaccine. J. Mass. Assn. Bds. Health, 1904/05, **14**, 231.

Note on the stability of the cultural characters of tubercle bacilli, with special reference to the production of capsules. Trans. Natl. Assn. Study and Prev. Tuberc., 1905, **1**, 211.

Pathological effects of periodic losses of blood; an experimental study. J. Med. Research, 1904, **12**, 385-406.

Reaction curve of tubercle bacilli from different sources in bouillon containing different amounts of glycerine. J. Med. Research, 1904/05, **13**, 405-408.

Some of the ways in which infection is disseminated. J. Mass. Assn. Bds. Health, 1904/05, **14**, 19.

Some problems in the life history of pathogenic microorganisms. Am. Med., 1904, **8**, 711-718; Science, 1904, n.s. **20**, 817.

Study of the tubercle bacilli isolated from three cases of tuberculosis of the mesenteric lymph nodes. Am. J. Med. Sci., 1904, n.s. **128**, 216; Trans. Assn. Am. Phys., 1904, **19**, 373-382.

1905

Fermentation tube in the study of anaerobic bacteria, with special reference to gas production and the use of milk as a culture medium, (with H. R. Brown and E. L. Walker). J. Med. Research, 1905/06, **14**, 193-206; Am. Pub. Health Assn. Rep., 1905, **31-2**, 229.

Medical research: its place in the university medical school. Bost. Med. and Surg. J., 1905, **152**, 466; Pop. Sci. Month., 1904/05, **66**, 515-530.

Relation of animal life to human disease. Bost. Med. and Surg. J., 1905, **153**, 485; Am. Pub. Health Assn. Rep., 1905, **31**, 328.

Research into the causes and antecedents of disease: its importance to society. Bost. Med. and Surg. J., 1905, **153**, 6.

Ueber einige Kulturmerkmale des Rauschbrandbazillus. Zeit. Infektionskr. Haustiere, 1905/06, **1**, 26-31.

1906

Actinomycosis, or lumpy jaw, (with D. E. Salmon). U. S. Bur. Anim. Indust., Circ. 96, 1906, 10 pp.

Parasitism of the tubercle bacillus and its bearing on infection and immunity. J. Am. Med. Assn., 1906, **46**, 1247; Harvey Lectures, 1905/06, 272.

Resistance of the red blood corpuscles of the horse to salt solutions of different tonicities before and after repeated withdrawals of blood, (with H. R. Brown). J. Med. Research, 1906, **15**, 425-447.

What is the relation between human and bovine tuberculosis, and how does it affect inmates of public institutions? Bost. Med. and Surg. J., 1906, **154**, 60; Am. J. Pub. Hyg., 1906, **14**, 516.

1907

Channels of infection in tuberculosis, together with some remarks on the outlook concerning a specific therapy. Bost. Med. and Surg. J., 1907, **157**, 420-427; Mass. Med. Soc. Med. Commun., 1907, **20**, 447.

Degree and duration of passive immunity to diphtheria toxin transmitted by immunized female guinea-pigs to their immediate offspring. J. Med. Research, 1907, **16**, 359-379.

Housefly as an agent in the dissemination of infectious diseases. Am. J. Pub. Hyg., 1907/08, n.s. **4**, 312.

Studies in mamalian tubercle bacilli. IV. Bacilli resembling the bovine type from four cases in man, (with H. R. Brown). J. Med. Research, 1907, **16**, 435-450.

1908

Experimental researches in tuberculosis, with special reference to etiology, pathology and immunity. Mass. St. Bd. Health, Month. Bull., 1908, **3**, 191-203.

Relation between human and animal tuberculosis, with special reference to the question of the transformation of human and other types of the tubercle bacillus. Bost. Med. and Surg. J., 1908, **159**, 707.

Some neglected facts in the biology of the tetanus bacillus: their bearing on the safety of the so-called biologic products. J. Am. Med. Assn., 1908, **50**, 929; Trans. Chicago Path. Soc., 1906/09, **7**, No. 4, 1.

Vaccination of cattle against tuberculosis. J. Med. Research, 1908, **18**, 451-485.

1909

Active immunity produced by so-called balanced or neutral mixtures of diphtheria toxin and antitoxin. J. Exp. Med., 1909, **11**, 241-256.

Animal diseases transmissible to man. Mass. St. Bd. Health Month. Bull., 1909, **4**, 264-276.

What is diseased meat and what is its relation to meat inspection? Am. J. Pub. Hyg., 1909, **19**, 397.

1910

Amoeba meleagridis. Science, 1910, n.s. **32**, 509.

Further studies on the immunizing effect of mixtures of diphtheria toxin and antitoxin, (with H. R. Brown). J. Med. Research, 1910, **23**, 433-449; Trans. Assn. Am. Phys., 1910, **25**, 212-222.

Insects as carriers of disease. Mass. St. Bd. Health Month. Bull., 1910, **5**, 112-119.

Intestinal amebiasis in the domestic pig. J. Med. Research, 1910, **23**, 423-432.
Note on the influence of infectious diseases upon a preexisting parasitism. J. Med. Research, 1910, **23**, 417-422.
Protective reaction of the host in intestinal coccidiosis of the rabbit. J. Med. Research, 1910, **23**, 407-415.
Reaction curve of the human and the bovine type of the tubercle bacillus in glycerine bouillon. J. Med. Research, 1910, **23**, 185-204.
What is the experimental basis for vaccine therapy? Bost. Med. and Surg. J., 1910, **163**, 275; Mass. Med. Soc. Med. Commun., 1910, **21**, 761.

1911

Ueber die pathogene Wirkung des Bacillus abortus Bang, (with M. Fabyan). Centr. Bakt., Abt. 1, Orig., 1911/12, **61**, 549-555.
Vaccination of cattle against tuberculosis. II. The pathogenic effect of certain cultures of the human type on calves. J. Med. Research, 1911, **25**, 1-33.

1912

Demonstration mikrokopischer Präparate von mit dem Bacillus des Abortus geimpften Meerschweinchen. Berl. klin. Woch., 1912, **49**, 715.
Demonstration verschiedener Anwendungen des Gärungskölbchens in der Bakteriologie, (with Oberstadt). Berl. klin. Woch., 1912, **49**, 716.
Histological examination of the tissues of dogs and monkeys. Rep. Board of Scientific Experts ("Remsen Board") of the U. S. Dept. Agri. on Coppered Peas, 1912, 453-461.
Parasitismus und Krankheit. Deut. Med. Woch., 1912, **38**, 276.

1913

Attempt to interpret present-day uses of vaccines. J. Am. Med. Assn., 1913, **60**, 1591.
Etiology of hay fever. Bost. Med. and Surg. J., 1913, **168**, 504.
Notes on the biology of the tubercle bacillus. J. Med. Research, 1913, **28**, 91-110.
Some bacteriological and environmental factors in the pneumonias of lower animals with special reference to the guinea-pig. J. Med. Research, 1913/14, **29**, 291-323.

1914

Agglutination affinities of a pathogenic bacillus from fowls (fowl typhoid) (Bacterium sanguinarium, Moore) with the typhoid bacillus of man, (with Carl Ten Broeck). J. Med. Research, 1914/15, **31**, 503-521.
Danger of transmitting disease by feeding offal to animals. N. Y. Dept. Health Month. Bull., 1914, **30**, 337.

Note on the relation between B. pullorum (Rettger) and the fowl typhoid bacillus (Moore), (with Carl Ten Broeck). J. Med. Research, 1914/15, **31**, 547-555.

Notes on two "atoxic" strains of diphtheria bacilli, (with H. R. Brown). J. Med. Research, 1914, **30**, 443-454.

Pathogenic action of the fowl typhoid bacillus with special reference to certain toxins, (with Carl Ten Broeck). J. Med. Research, 1914/15, **31**, 523-546.

Study of strepotococci isolated from certain presumably milk-borne epidemics of tonsillitis occurring in Massachusetts in 1913 and 1914, (with H. R. Brown). J. Med. Research, 1914/15, **31**, 455-502.

1915

Anatomical and histological expression of increased resistance towards tuberculosis in cattle following the intravenous injection of human and attenuated bovine tubercle bacilli. J. Med. Research, 1915, **32**, 455-469; Trans. Assn. Am. Phys., 1915, **30**, 7-19.

Further investigation into the etiology of the protozoan disease of turkeys known as blackhead, enterohepatitis, typhlitis, etc. J. Med. Research, 1915/16, **33**, 243-270.

Scholarship in medicine. Bost. Med. and Surg. J., 1915, **172**, 121.

Vaccination of cattle against tuberculosis. III. The occasional persistence of the human type of tubercle bacillus in cattle, (with M. Fabyan). J. Med. Research, 1915, **32**, 523-537.

1916

Aberrant intestinal protozoan parasites in the turkey. J. Exp. Med., 1916, **23**, 293-300.

Certain aspects of natural and acquired resistance to tuberculosis and their bearings on preventive measures. Mellon Lecture, Univ. Pittsburgh, 1916, No. 2, 39 pp.; J. Am. Med. Assn., 1917, **68**, 669-674, 764-769.

Underlying problems of immunization. J. Am. Med. Assn., 1916, **66**, 1740; Med. Rec., 1916, **89**, 974; Trans. Cong. Am. Phys. and Surg., 1916, **10**, 99-109.

1917

Note on coccidia in sparrows and their assumed relation to blackhead in turkeys, (with E. W. Smillie). J. Exp. Med., 1917, **25**, 415-420.

Significance of laboratory research in medical education. Albany Med. Ann., 1917, **38**, 351.

Some field experiments bearing on the transmission of blackhead in turkeys. J. Exp. Med., 1917, **25**, 405-414.

1918

Coccidiosis in young calves, (with H. W. Graybill). J. Exp. Med., 1918, **28**, 89-108.

A pleomorphic bacillus from pneumonic lungs of calves simulating actinomyces. J. Exp. Med., 1918, **28**, 333-334.
Spirilla associated with disease of the fetal membranes in cattle (infectious abortion). J. Exp. Med., 1918, **28**, 701-719.

1919

Bacteriology of bovine abortion with special reference to acquired immunity. J. Exp. Med., 1919, **30**, 325-339.
Characteristic localization of Bacillus abortus in the bovine fetal membranes. J. Exp. Med., 1919, **29**, 451-456.
The etiological relation of spirilla (Vibrio fetus) to bovine abortion. J. Exp. Med., 1919, **30**, 313-323.
Some morphological and biological characters of the spirilla (Vibrio fetus, n. sp.), associated with disease of the fetal membranes in cattle, (with M. S. Taylor). J. Exp. Med., 1919, **30**, 299-311.

1920

Blackhead in chickens and its experimental production by feeding embryonated eggs of Heterakis papillosa, (with H. W. Graybill). J. Exp. Med., 1920, **32**, 143-152.
Epidemiology of blackhead in turkeys under approximately natural conditions, (with H. W. Graybill). J. Exp. Med., 1920, **31**, 633-645.
Further studies on the etiological rôle of Vibrio fetus, (with R. B. Little and M. S. Taylor). J. Exp. Med., 1920, **32**, 683-689.
The importance of research in animal pathology to agriculture. Address delivered at the dedication of the Animal Pathology and Hygiene Laboratories of the University of Nebraska, College of Agriculture, 1920.
Inhibitory action of paratyphoid bacilli on the fermentation of lactose by Bacillus coli, (with D. E. Smith). J. Gen. Physiol., 1920/21, **3**, 21-33.
Mycosis of the bovine fetal membranes due to a mould of the genus Mucor. J. Exp. Med., 1920, **31**, 115-122.
Production of a fatal blackhead in turkeys by feeding embryonated eggs of Heterakis papillosa, (with H. W. Graybill). J. Exp. Med., 1920, **31**, 647-655.
Theories of susceptibility and resistance in relation to methods of artificial immunization. Proc. Inst. Med., Chicago, 1920/21, **3**, 243-265.
The relation of animal to human diseases. Nelson's Loose-Leaf Medicine, 1920, **7**, 399-413.

1921

Bovine tuberculosis as a contributory source of human tuberculosis. Proc. 47th Ann. Meeting N. J. Sanitary Assn., 1921, 21-24.
The capsules or sheaths of Bacillus actinoides. J. Exp. Med., 1921, **34**, 593-598.

The etilogical relation of Bacillus actinoides to broncho-pneumonia in calves. J. Exp. Med., 1921, **33**, 441-469.
Parasitism as a factor in disease. Science, 1921, **54**, 99-108; Trans. Assn. Am. Phys., 1921, **36**, 172.
Remarks on the etiology of infectious abortion in cattle. Cornell Vet., 1921, **11**, 85-91.

1922

Cow serum as a substitute for colostrum in new-born calves, (with R. B. Little). J. Exp. Med., 1922, **36**, 453-468.
Significance of colostrum to the new-born calf, (with R. B. Little). J. Exp. Med., 1922, **36**, 181-198.

1923

Absorption of specific agglutinins in homologous serum fed to calves during the early hours of life, (with R. B. Little). J. Exp. Med., 1923, **37**, 671-683.
Further studies on the etiological significance of Vibrio fetus. J. Exp. Med., 1923, **37**, 341-356.
Source of agglutinins in the milk of cows, (with M. L. Orcutt and R. B. Little). J. Exp. Med., 1923, **37**, 153-174.
Studies in vaccinal immunity towards disease of the bovine placenta due to Bacillus abortus (infectious abortion), (with R. B. Little). R.I.M.R. Monograph 19, 1923, 124 pp.

1924

Proteinuria in new-born calves following the feeding of colostrum, (with R. B. Little). J. Exp. Med., 1924, **39**, 303-312.
Some aspects of the tuberculosis problem from the experimental and comparative standpoint. Edinburgh Med. J., 1924, **31**, 176-181.
Some biological and economic aspects of comparative pathology. Edinburgh Med. J., 1924, **31**, 221-240.
Some cultural characters of Bacillus abortus (Bang) with special reference to CO_2 requirements. J. Exp. Med., 1924, **40**, 219-232.

1925

The bacteriology of the intestinal tract of young calves with special reference to the early diarrhea ("scours"), (with M. L. Orcutt). J. Exp. Med., 1925, **41**, 89-106.
Encephalitozoon cuniculi as a kidney parasite in the rabbit, (with L. Florence). J. Exp. Med., 1925, **41**, 25-35.
Focal interstitial nephritis in the calf following interference with the normal intake of colostrum. J. Exp. Med., 1925, **41**, 413-425.
Hydropic stages in the intestinal epithelium of new-born calves. J. Exp. Med., 1925, **41**, 81-88.

Pneumonia associated with Bacillus abortus (Bang) in fetuses and newborn calves. J. Exp. Med., 1925, **41**, 639-647.
The significance of colostrum in the prevention of the diseases of young calves. Cornell Vet., 1925, **15**, 173-180.

1926

Further data on the effect of vaccination against bovine infectious abortion, (with R. B. Little). J. Exp. Med., 1926, **43**, 327-330.
The problem of natural and acquired resistance to tuberculosis. Am. Rev. Tuberc., 1926, **14**, 485-495.
The relation of Bacillus abortus from bovine sources to Malta fever. J. Exp. Med., 1926, **43**, 207-223.
Remarks on the cooperation of science and practice in tuberculosis. Am. Rev. Tuberc., 1926, **14**, 598-599.
Variations in CO_2 requirements among bovine strains of Bacillus abortus. J. Exp. Med., 1926, **43**, 317-325.

1927

The passing of disease from one generation to another and the processes tending to counteract it. Intern. Clinics, 1927, **3**, Ser. 37, 1-15.
The relation between invasion of the digestive tract by para-typhoid bacilli and disease, (with H. A. M. Tibbetts). J. Exp. Med., 1927, **45**, 337-352.
The segregation of lambs at birth and the feeding of cow's milk in the elimination of parasites, (with E. R. Ring). J. Parasit., 1927, **13**, 260-269.
Studies on a paratyphoid infection in guinea pigs. I. Report of a natural outbreak of paratyphoid in a guinea pig population, (with J. B. Nelson). J. Exp. Med., 1927, **45**, 353-363.
Studies on a paratyphoid infection in guinea pigs. II. Factors involved in the transition from epidemic to endemic phase, (with J. B. Nelson). J. Exp. Med., 1927, **45**, 365-377.
Studies on pathogenic B. coli from bovine sources. I. The pathogenic action of culture filtrates, (with R. B. Little). J. Exp. Med., 1927, **46**, 123-131.
Studies on pathogenic B. coli from bovine sources. II. Mutations and their immunological significance, (with G. Bryant). J. Exp. Med., 1927, **46**, 133-140.
Studies on pathogenic B. coli from bovine sources. III. Normal and serologically induced resistance to B. coli and its mutant. J. Exp. Med., 1927, **46**, 141-154.
Vibrios from calves and their serological relation to Vibrio fetus, (with M. L. Orcutt). J. Exp. Med., 1927, **45**, 391-397.

1928

Animal reservoirs of human disease with special reference to microbic variability. Bull. N. Y. Acad. Med., 1928, **4**, Ser. 2, 476-497.

The decline of infectious diseases in its relation to modern medicine. J. Prev. Med., 1928, **2**, 345-363; Trans. Congr. Am. Phys. and Surg., 1928, **14**, 1-18; Canadian Med. Assn. J., 1928, **19**, 283-287 (abridged).

The relation of the capsular substance of B. coli to antibody production. J. Exp. Med., 1928, **48**, 351-361.

1929

Hideyo Noguchi. 1876-1928. Bull. N. Y. Acad. Med., 1929, **5**, Ser. 2, 877-886.

The influence of research in bringing into closer relationship the practice of medicine and public health activities. Am. J. Med. Sci., 1929, **178**, 741-747.

Undulant fever. Its relation to new problems in bacteriology and public health. Medicine, 1929, **8**, 193-209.

Undulant fever. (Abstract of an address given before the Annual State Health Conference at Saratoga Springs, N. Y., June 25, 1929). Health News, Aug. 5, 1929, **6**, 121-122.

A strain of Bacillus abortus from swine. J. Exp. Med., 1929, **49**, 671-679.

1930

The immunological significance of colostrum. I. The relation between colostrum, serium, and the milk of cows normal and immunized towards B. coli. J. Exp. Med., 1930, **51**, 473-481.

The immunological significance of colostrum. II. The initial feeding of serum from normal cows and cows immunized towards B. coli in place of colostrum, (with R. B. Little). J. Exp. Med., 1930, **51**, 483-492.

The immunological significance of colostrum. III. Intranuclear bodies in renal disease of calves. J. Exp. Med., 1930, **51**, 519-529.

ADDENDA

1886-1891

Material provided for the following reports of the Chief of the Bureau of Animal Industry of the U. S. Department of Agriculture:

2nd Annual Report for the year 1885, 1886, pp. 184-246.
3rd Annual Report for the year 1886, 1887, pp. 20-100.
4th/5th Annual Report for the year 1887/8, 1889, pp. 49-166.
6th/7th Annual Report for the year 1889/90, 1891, pp. 28-62.

1927

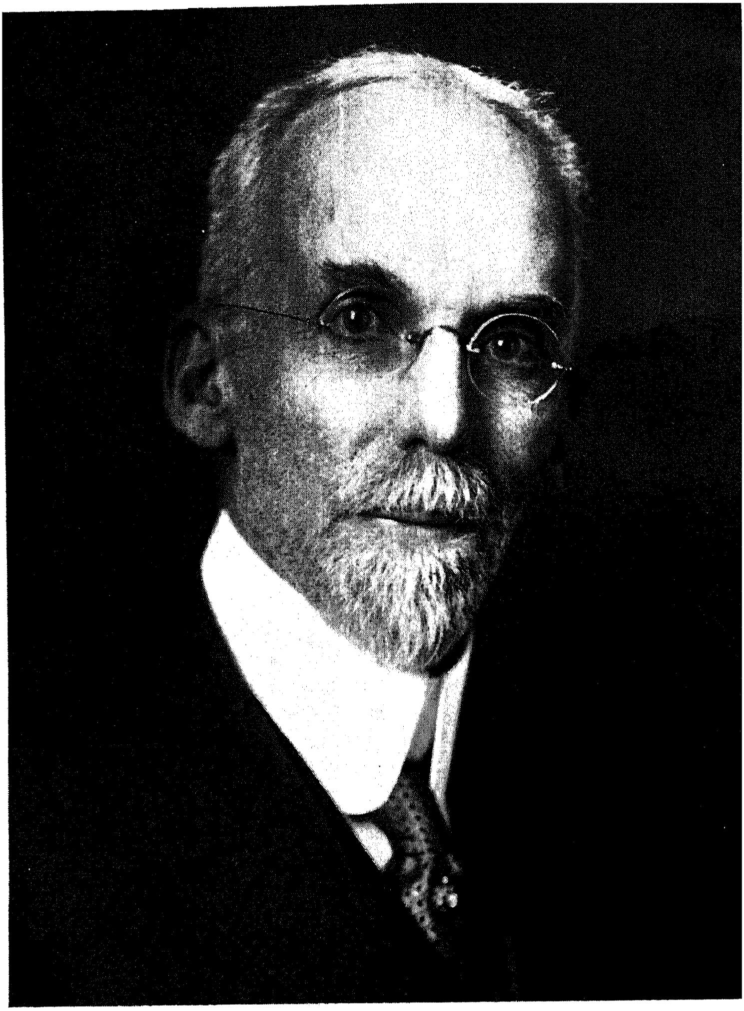
Discussion in "Public Health Progress and Race Progress—Are They Incompatible?", by H. S. Jennings, pp. 11-14, reprinted from Trans. 23rd Ann. Meet. Natl. Tuberc. Assn., 1927.

1930

Foreword in "Stalkers of Pestilence," by Wade W. Oliver, New York, 1930, pp. xi-xv.

1934

Parasitism and Disease. Princeton University Press, 1934.



B. L. Robinson.

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVII—THIRTEENTH MEMOIR

BIOGRAPHICAL MEMOIR

OF

BENJAMIN LINCOLN ROBINSON

1864–1935

BY

M. L. FERNALD

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1936

BENJAMIN LINCOLN ROBINSON

1864–1935

By M. L. Fernald

Benjamin Lincoln Robinson was born at Bloomington, Illinois, November 8, 1864, the son of James Harvey and Latricia Maria (Drake) Robinson, and died at his summer home in Jaffrey, New Hampshire, July 27, 1935. His ancestry both on his father's and his maternal grandmother's side was chiefly of English protestant stock who early immigrated to colonial Massachusetts, he being a descendant in the eighth generation from the Rev. John Robinson, a Puritan pastor at Leyden. His maternal grandfather, the Rev. Benjamin Bradner Drake, born at Borodine, New York, was in part descended from Scotch Irish stock which had settled in New York State about 1735. The parents of Benjamin Lincoln Robinson, both born in New York State, settled in Illinois about 1840, the father there engaging in business and becoming the president of the First National Bank in Bloomington.

Benjamin was the youngest of eight children. He was educated at home until his tenth year, then for six years in the public schools of his native city. Thereafter he prepared for college at the Illinois Normal School at Normal, where he came under the stimulating instruction of Edward J. James, later distinguished as president of the University of Illinois. In the autumn of 1883 Robinson entered Williams College; but, finding the opportunities there to specialize in botany less than he had anticipated, he remained only three months and returned home and prepared himself for Harvard College, which he entered the following autumn. At Harvard he devoted himself chiefly to scientific studies, with special attention to botany under the guidance of Goodale and Farlow, graduating (A. B.) in 1887. Immediately after graduation, on June 29, 1887, he married, at Hennepin, Illinois, Margaret Louise Casson, daughter of William Henry and Mary Ann (MacMahon) Casson, a woman of great social activity and musical accomplishment,

who later, in Cambridge, became prominent through her energetic opposition to social trends which she felt to be detrimental.

In the summer of 1887 the young couple went to Europe, Robinson starting in October his graduate studies with Graf zu Solms-Laubach at the University of Strasburg, majoring in botany, with minors in geology and mineralogy. His dissertation, in the field of plant-anatomy, led to his Ph. D. in 1889; and after a brief period of study under Strasburger at Bonn, he returned to Cambridge in the autumn of 1890 and became assistant to Sereno Watson, the Curator of the Gray Herbarium of Harvard University. The Robinsons returned to Cambridge with keen enthusiasm for Germanic culture and from 1891 to 1894 Robinson conducted a course at Harvard in scientific German.

On the death of the venerable and kindly Sereno Watson, in 1892, Robinson, then in his 29th year, was appointed to the curatorship; and from that time until his death his work for and at the Herbarium was essentially continuous, except for frequent absences due to frail health and six trips to Europe, partly for special botanical studies in the great herbaria there. During all this time the present writer was closely associated with him, having come to the Gray Herbarium as junior assistant to Sereno Watson in the spring of 1891. He may, therefore, write of certain of Robinson's traits, works and ambitions from an intimate knowledge of them.

At the time of his appointment as Curator, the Gray Herbarium was an adjunct of the Harvard Botanic Garden, the two, during the active life of Asa Gray, having been interdependent and with mutual scientific significance. Soon after Robinson, of a newer generation not associated with the botanical activities of Gray, took charge of the Herbarium, the Director of the Garden, who was also then active in his phenomenal development of the Botanical Museum, found it inexpedient to secure the funds for so many needy establishments and in 1897 asked that the Gray Herbarium look in the future for its own support. This critical situation is clearly described by Robinson himself:

"Until the middle 'nineties the Herbarium held, with respect

to its support, a rather anomalous position. Though entered in the Treasurer's Report in the College accounts along with Appleton Chapel and the Hemenway Gymnasium, it was in no way financed by the College. The public, on the other hand, very naturally supposed the Herbarium to be a part of the Garden and supported by it. Yet it never received any income from that source, though the Garden with the utmost fairness shared with it such gifts for current expenses as were contributed by a joint Visiting Committee. In 1897, Goodale, then Director of the Garden and Botanical Museum and thus responsible for the still precarious support of both, decided that he could be of no further aid to the Herbarium, and requested that it might be provided with a committee of its own, and henceforth recognized as an independent establishment by the Governing Boards. That course was immediately taken.

"This was the most critical period for the Herbarium. From interest on its fund and from diminishing returns on copyrights bequeathed by Gray, it had an income of about $3600, scarcely half the annual expenses, which could not be reduced without seriously damaging the interests of the scientific collections.

"These matters were laid before the newly appointed Visiting Committee, a strong and sympathetic group. Most of its members had been personal friends of Gray, or had studied in his classes. The Committee took immediate and helpful interest. By gifts for present use the existing difficulties were relieved. Attention was then turned to endowment in order to assure the future. Within a few months the Curator was able to announce to the Committee an offer (at the time anonymously made by Mrs. Gray) of the sum of twenty thousand dollars to endow an Asa Gray Professorship of Systematic Botany, a position to be united with the curatorship of the Herbarium. The offer was conditional on the raising of thirty thousand dollars as an Asa Gray Memorial Fund for the further endowment of the Herbarium. Somewhat more than this sum was raised by June, 1899, the proposed memorial professorship was founded, and Robinson was appointed as its first incumbent."

Only those who knew Robinson's natural reserve and sensitiveness, his quiet dignity and scholarly training and his high

scientific ambitions can realize the dread he had of directly asking financial aid for himself and his work. The anomalous and almost resented position of some of the important and internationally famous research establishments of the University perpetually disturbed him. He naturally felt, as did many of his associates, that, when Harvard University accepted the Gray Herbarium as one of its integral parts, its obligation should not have ceased with merely the cordial acceptance of the gift. Such, however, was the attitude of the University administration and all research establishments not directly under the faculties of instruction were then and still are left to starve or to beg outside the University. Although utterly lacking the cheer-leading and "hail-fellow-well-met" approach of the ordinary canvasser, and handicapped by a manner somewhat stiff and over-formal as well as by a subject with little spectacular appeal, Robinson, rising to the necessities of the situation and aided by loyal friends, won by his sincerity and his unselfish loyalty to his unappreciative University, the aid of a small group of helpers; and at the close of his curatorship he had been instrumental in increasing the endowment of the Gray Herbarium from $18,155 to $526,000. That in itself, in view of the perpetual handicaps, was a major contribution to systematic botany, but the nervous strain and worry involved were tremendous.

When he took over the care of the Gray Herbarium the fame of the establishment abroad was already great, through the monumental studies for many years by Asa Gray, the painstaking and invaluable papers of Watson and the pioneer publications of their young assistants and advanced students, L. H. Bailey, Kingo Miyabe, and others. The young Curator, starting in with a boy-assistant, had a major task to bring his institution up to the famous position it had previously occupied. Cautious in the selection of assistants in this work and prevented by the financial restrictions already referred to from maintaining and promoting a staff of expert workers, as is done in the large herbaria of the Old World, Robinson utilized all available young men of real promise until the pressure of limitation of funds forced their release to more remunerative positions elsewhere. Thus, for more than forty years, the scientific studies

and output were maintained and many of our leading botanists have gone out to their life-work with at least a few years of the training which their temporary assistantships had furnished. The closing years of Robinson's administration found the Gray Herbarium ranking as one of the seven leading research establishments of the world in its field of systematic botany, with the Curator and members of the staff bringing to the University more than the old quota of world-recognition as outstanding scientists.

Robinson's first task of purely scientific character was the editing and completion of extended manuscripts left by Gray and by Watson. These were chiefly portions of the *Synoptical Flora of North America*. After several years devoted to this work it became evident that the task of carrying forward to completion the *Synoptical Flora* was too vast for a single man drafted into the enterprise and with essentially no help.

During the progress of this work and while gaining a familiarity with the invaluable content of the Gray Herbarium and the irreplaceable records of close scientific study of its material, Robinson became more and more impressed with the tremendous loss to science should the collections (hay-dry plants mounted on paper and kept in dusty wooden cabinets in a building of brick and wood) or the building catch fire. Accordingly his efforts turned to a new problem. He endeavored to make a combination of the Gray Herbarium, situated on its historic site, with the Cryptogamic Herbarium (now the Farlow Herbarium), which was then housed in the Museum building. For nine years he vainly pushed this ambition for a joint building in the neighborhood of the Museums and Biological Laboratories; then, having received little encouragement, and the absolute congestion of the material in the Gray Herbarium needing relief, he was forced to development on the old site. Through friends of the establishment the original building was gradually rebuilt as a noncombustible structure, setting the highest standards of equipment, lighting and arrangement for its special purpose. This new building, already outgrown, though erected between 1909 and 1915, was almost wholly of Robinson's planning. Finding that the plans drawn up by an assigned architect called for large expenditures for adornments and needless ex-

tras, Robinson took matters into his own hands, drew the plans himself, studied and prepared specifications for the furnishings and finally, with the collaboration of a young architect who saw the value of the non-professional plans, put through a building which is cited in Europe and in many parts of America as a model for its purpose. I intentionally dwell upon Robinson's connection with the architectural plans because their preparation and execution were for several years his life, and his friends all recognized that the building which houses the Gray Herbarium was to him as a dearly loved child.

During the first half of his curatorship the demand for a revision of Gray's *Manual of Botany* became urgent. Accordingly, with the collaboration of the present writer, this task was undertaken and a new edition was issued in 1908. In these years Robinson's original publications were based largely on collections brought back by various explorers from Mexico and the Galapagos Islands; but gradually it became apparent that the herbaria of the United States lacked adequate reference material from the vast continent of South America. Prompt to recognize the need, Robinson effected coöperation with the New York Botanical Garden and the United States National Museum and, later, with other institutions, an intensive botanical exploration in various significant sections of South America was begun. The coöperation of the South American botanists was also enlisted, largely through Robinson's younger associates, Drs. Ivan M. Johnston and Lyman B. Smith, who had each visited South American countries, and a mutual exchange of great importance thus established.

In 1895 Robinson, joining Farlow, Goodale, Thaxter, and a small group of amateurs, founded the New England Botanical Club, of which he served as president from 1906 to 1908. From its beginning in 1899 through 1928 (thirty volumes) he was editor-in-chief of the Club's journal, *Rhodora,* a noteworthy scientific publication in its special field.

During his later years he became more and more absorbed in monographic studies in the vast *Eupatorium* tribe of the family *Compositae*. Himself not an active field-botanist, he nevertheless stimulated others to assemble material in his chosen

group, maintaining that the material already assembled and unorganized in the world's great herbaria and such new material as naturally came in from explorers in the American tropics was more than he could ever handle. Searching through the dust-covered bundles of specimens in Paris or elsewhere he would unearth unstudied material of his group which sometimes had lain unnoticed for a century or more, since its collection in then undeveloped areas of South America. Such old and forgotten collections of the past explorers were his delight and at the time of his death he was looking forward to years of study of the series of *Eupatorium* and its allies sent for critical and authoritative comparisons from the great herbaria of England, France and Germany.

Reference has been made to Robinson not being a field-botanist. In his youth he apparently did some field-work, and in 1894 he organized and carried through a collecting trip to Newfoundland. In the early days of the New England Botanical Club he went frequently on short local trips, and he greatly enjoyed the companionship of friends in the field; but he tired easily and was often forced to forego comparatively simple excursions. Gradually his field-work became restricted to pastimes in periods of enforced winter or early spring vacations in Bermuda or in the South, where he went to recuperate after serious pulmonary or related difficulties. But, although forced by his frail constitution to refrain from the most active of field-work, Robinson was always ready to encourage exploration of serious and obviously intelligent character. Many young men owe much to his readiness to aid or to seek aid for their enterprises and many important series of specimens are the result of his foresight in encouraging their collection.

Robinson did not take part in active instruction in botany at Harvard; but he guided toward the doctorate a number of graduate students and he did much to form the literary style and train the appreciation of it in many of our best scientific workers. With a keen feeling for language, both classical and modern, furthered by unusual familiarity with the best in the world's literature (including Russian and other non-latin literatures) and art, himself being an amateur musician, he abhorred

the sloppy and crude form or lack of finish in much that finds publication in scientific journals. Papers for publication under his editorial eye were truly edited and many an author of a technical article may well have been surprised, if he had the perception to note it, by the finished style in which his badly written contribution appeared in print. So conscientious was Robinson, that he would spend many evenings simply rewriting or recasting articles for publication in *Rhodora;* and his graduate students and assistants, especially if their mastery of English was deficient, went through a vigorous training which made their finished work fully worthy of their master.

To those who met Robinson only casually his outstanding traits were reserve or shyness and a formal courtesy reminiscent of an earlier epoch. His unfailing courtesy and his consideration for others were appreciated by those who were his daily associates. Forced against his wish to restrict expansion and to trim his institutional activities to the limits of a very limited budget, his adverse decisions were always graciously announced and the affection and loyalty of his group of workers always maintained. In fact, one who has had much executive experience in many lands thus wrote of him:

"Quiet, unassuming, courteous in the extreme, a conscientious and efficient worker, a gentleman in the truest sense of the word, Dr. Robinson will be missed by his colleagues and associates at Harvard, by that large group of botanists who were trained at Cambridge during his long tenure of office, and by that larger group of American and foreign botanists who have had the privilege of working for shorter or longer periods with the treasures of the Gray Herbarium. Under Dr. Robinson's leadership the Gray Herbarium attained a spirit of "Gemütlichkeit" unequalled in any other botanical institution with which I am personally familiar. The loss of his services to botanical science is a heavy one, but he leaves behind him a magnificent record of accomplishment."

Another, the former Keeper of Botany at the British Museum, has stated a similar impression:

"I remember no more welcome or charming visitor to the British Museum than B. L. Robinson, whose long service to

floristic botany at Harvard was closed by death on July 27. . . . One remembers also his tactful co-operation at certain Botanical Congresses, especially at Vienna, in 1905, where he represented the more stable school of nomenclature as opposed to the somewhat revolutionary Neo-American School. But that is ancient history. There are also pleasant memories of a day at Boston, after the Ithaca Congress in 1926, when Robinson did the honours of the Gray Herbarium, the last word in safety—furniture and fittings all of steel as on a battleship—and organized equipment."

Robinson, as so gracefully stated by Rendle, was well known and highly respected in the leading botanical centers of Europe; he had made six trips abroad for scientific purposes, studying in the great herbaria at Kew, the British Museum, Paris, Geneva, Vienna, Berlin and Copenhagen. At home he had served as president of the Botanical Society of America (1900), as vice-president of the American Association for the Advancement of Science (1905) and as president of the New England Botanical Club (1906-1908). He was a member of the Commission internationale de Nomenclature botanique at the International Botanical Congress at Vienna (1905), a vice-president of the International Congress at Brussels (1910) and a member of the Commission de Nomenclature générale appointed at Ithaca (1926).

Besides being active in the organizations already mentioned, he was a fellow of the American Academy of Arts and Sciences, a member of the National Academy of Sciences, of the Washington Academy of Sciences, of the Boston Society of Natural History, of the Vermont Botanical Club, of the Massachusetts Horticultural Society and of the Phi Beta Kappa Society, a corresponding member of the Deutsche Botanische Gesellschaft, of the Botanischer Verein der Provinz Brandenburg, of the Société botanique de Genève, of the Czechoslovakian Botanical Society, a foreign member of the Linnean Society of London and of the Societas pro Fauna et Flora Fennica, honorary member of the Chilean Society of Natural History, honorary academician of the Museum of the National University

of La Plata, and correspondent of the Academy of Natural Sciences of Philadelphia.

In 1904 he received the bronze medal of the Louisiana Purchase Exposition at St. Louis and in 1929 the Centennial Gold Medal of the Massachusetts Horticultural Society "for eminent service to botany."

For many years suffering from obscure pulmonary difficulties and, consequently, frail and appearing older than his years, in 1931 Robinson had a critical illness from which he never really rallied. The death of Mrs. Robinson in May, 1932, still further broke him; but he recovered sufficiently to continue his work interruptedly, though his weakness was distressingly apparent to his associates and friends. He died peacefully at his summer home, his mind, during his last illness, constantly on the Eupatoriums and the Gray Herbarium, the two great interests to which, up to the last, he hoped to return.

BIBLIOGRAPHY

(Mere Notices or Abstracts without original discussion are omitted)

Compiled by Lily M. Perry

1887

Notes on the Genus Taphrina. Ann. Bot. i. 163-176.

1889

Beiträge zur Kenntniss der Stammanatomie von Phytocrene macrophylla Bl. Bot. Zeitung, xlvii. 645-657, 661-671, 677-686, 693-701, pl. 10. Strassburg. (Inaugural Dissertation) 1-22, pl.

1890

On the Stem-structure of Iodes tomentella Miq. and Certain Other Phytocreneae. Ann. Jard. Bot. Buitenzorg, viii. 95-121, pl. 18, 19.

1891

Descriptions of New Plants, chiefly Gamopetalae, collected in Mexico by C. G. Pringle in 1889 and 1890. Proc. Amer. Acad. xxvi. 164-176 (Contrib. Gray Herb. i.).

New Plants collected by W. G. Wright in Western Mexico. Bot. Gaz. xvi. 340-342.
Silphium laciniatum L. Ibid. 114, 115.
Two New Plants from the Cascade Mountains. Ibid. 43-45, pl. 6.
Two Undescribed Species of Apodanthes. Ibid. 82-84, pl. 9.
[Review.] Cultures experimentales dans les Alpes et les Pyrénées; by Gaston Bonnier. Am. Journ. Sci. ser. 3, xli. 255, 256.
[Review.] Die Gattung Phyllostylon und ihre Beziehungen zu Samaroceltis; by Dr. P. Faubert. Ibid. 166.
[Review.] Eine Notiz über das Verhalten der Chlorophyllbänder in den Zygoten der Spirogyraarten; by Vincent Chmielevsky. Ibid. 166.
[Review.] Gray's Manual of Botany; reprint of the sixth edition, edited by Dr. Sereno Watson and Prof. J. M. Coulter, 1891. Ibid. 441, 442.
[Review.] Hypertrophie des lenticelles chez la pomme de terre et quelques autres plantes; by H. Devaux. Ibid. 442.
[Review.] The Missouri Botanical Garden, St. Louis, 1890. Ibid. 336.
[Review.] The Nursery-Book; a Complete Guide to the Multiplication and Pollination of Plants; by L. H. Bailey. Ibid. 442.
[Review.] On Isoëtes lacustris L.; by J. Bretland Farmer. Ibid. 334.
[Review.] Neue Untersuchungen über den Blüthenanschluss; by Karl Schumann. Ibid. 162, 163.
[Review.] Notes on Corticium Oakesii B. & C. and Michenera Artocreas B. & C.; by George James Peirce. Ibid. 163, 164.
[Review.] Plantae Europeae,—Enumeratio systematica et synonymica plantarum phanerogamicarum in Europa sponte crescentium vel mere inquilinarum; by Dr. K. Richter. Ibid. 163.
[Review.] Die Protoplasmaverbindungen zwischen benachbarten Gewebeselementen in der Pflanze; by F. Kienitz-Gerloff. Ibid. 518-520.
[Review.] Protoplasmaverbindungen bei Algen; by F. G. Kohl. Ibid. 520.
[Review.] Recherches anatomiques sur les hybrides; by M. Marcel Brandza. Ibid. 74, 75.
[Review.] Recherches sur la croissance terminale de la tige des phanerogames; by H. Douliot. Ibid. 253, 254.
[Review.] Recherches sur l'origine morphologique du liber interne; by Prof. M. Lamounette. Ibid. 164-166.
[Review.] Silva of North America; by Prof. C. S. Sargent, illustrated from drawings by C. E. Faxon. Ibid. 73-74.
[Review.] Studien über die Tribus der Gaertnereen Benth.-Hook.; by H. Solereder. Ibid. 334, 335.
[Review.] Typical Elms and Other Trees of Massachusetts. Introduction by Wendell Holmes, descriptive text by Lorin L. Dame, illustrations by Henry Brooks. Ibid. 254.
[Review.] Ueber die Balken in den Holzelementen der Coniferen; by Carl Müller. Ibid. 254, 255.

[Review.] Uber die Verbreitung der karpotropischen Nutationskrümmungen der Kelch-, Hull-, und ähnlicher Blätter und der Blüthenstiele; by Anton Hansgirg. Ibid. 335, 336.
[Review.] The West American Oaks; by E. L. Greene. Ibid. 333, 334.

1892

Descriptions of New Plants collected in Mexico by C. G. Pringle in 1890 and 1891, with Notes on a Few Other Species. Proc. Amer. Acad. xxvii. 165-185 (Contrib. Gray Herb. ii.).

1893

[with Henry Eliason Seaton.] Additions to the Phaenogamic Flora of Mexico discovered by C. G. Pringle in 1891-92. Proc. Amer. Acad. xxviii. 103-115 (Contrib. Gray Herb. iii.).
George Vasey. Ibid. 401-403.
The North American Sileneae and Polycarpeae. Ibid. 124-155 (Contrib. Gray Herb. v.).
[with H. E. Seaton.] Two New Plants from Washington. Bot. Gaz. xviii. 237, 238.
The Herbarium. Ann. Rep. of the President and Treasurer of Harvard College, 1891-1892. 161-163.

1894

Descriptions of New and hitherto Imperfectly Known Plants Collected in Mexico by C. G. Pringle in 1892 and 1893. Proc. Amer. Acad. xxix. 314-325 (Contrib. Gray Herb. vi., in part).
Miscellaneous Notes and New Species. Ibid. 327-330 (Contrib. Gray Herb. vi., in part).
Notes upon the Genus Galinsoga. Ibid. 325-327 (Contrib. Gray Herb. vi., in part).
The North American Alsineae. Ibid. 273-313 (Contrib. Gray Herb. vi., in part).
[with Jesse More Greenman.] Further New and Imperfectly Known Plants collected in Mexico by C. G. Pringle in the Summer of 1893. Ibid. 382-394 (Contrib. Gray Herb. vii.).
[with Merritt Lyndon Fernald.] New plants collected by Messrs. C. V. Hartman and C. E. Lloyd upon an Archaeological Expedition to Northwestern Mexico under the Direction of Dr. Carl Lumholtz. Ibid. xxx. 114-123 (Contrib. Gray Herb. viii.).
The Herbarium. Ann. Rep. of the President and Treasurer of Harvard College, 1892-93. 179-182.

1895

The Nomenclature Question. On the application of "once a synonym always a synonym" to binomials. Bot. Gaz. xx. 261-263.

The Nomenclature Question. A further discussion of the Madison rules. Ibid. 370-371.

On the "List of Pteridophyta and Spermatophyta of Northeastern America" prepared by the Nomenclature Committee of the Botanical Club. Ibid. 97-103.

[with J. M. Greenman.] On the Flora of the Galapagos Islands as shown by the Collection of Dr. G. Baur. Amer. Journ. Sci. ser. 3, l. 135-149 (Contrib. Gray Herb. ix., in part).

[with J. M. Greenman.] Miscellaneous New Species. Ibid. 175, 176 (Contrib. Gray Herb. ix., in part).

[with J. M. Greenman.] New and Noteworthy Plants chiefly from Oaxaca collected by Messrs. C. G. Pringle, L. C. Smith and E. W. Nelson. Ibid. 150-168 (Contrib. Gray Herb. ix., in part).

[with J. M. Greenman.] A Synoptic Revision of the Genus Lamourouxia. Ibid. 169-174 (Contrib. Gray Herb. ix., in part).

Synoptical Flora of North America. Vol. I. Fascicle i; by Asa Gray and Sereno Watson. Continued and edited by Benjamin Lincoln Robinson. i-ix and 1-208.

The Herbarium. Ann. Rep. of the President and Treasurer of Harvard College, 1893-94. 179-182.

1896

[with J. M. Greenman.] A New Genus of Sterculiaceae and Some Other Noteworthy Plants. Bot. Gaz. xxii. 168-170.

[with W. Deane.] A New Viburnum from Missouri. Ibid. 166, 167, pl. 8.

Notes on Two Species of Brassica. Ibid. 252, 253.

The Fruit of Tropidocarpum. Erythea, iv. 109-119, pl. 3.

[with Hermann von Schrenk.] Notes on the Flora of Newfoundland. Canad. Rec. Sci. vii. 3-31.

Nymphaea tetragona Georgi. Garden and Forest, ix. 134, fig. 16.

[with J. M. Greenman.] Descriptions of New or Little Known Phanerogams chiefly from Oaxaca. Proc. Amer. Acad. xxxii. 34-51 (Contrib. Gray Herb. x., in part).

[with J. M. Greenman.] A Provisional Key to the Species of Porophyllum ranging north of the Isthmus of Panama. Ibid. 31-33 (Contrib. Gray Herb. x., in part).

[with J. M. Greenman.] Revision of the Mexican and Central American Species of the Genus Calea. Ibid. 20-30 (Contrib. Gray Herb. x., in part).

[with J. M. Greenman.] Revision of the Genus Tridax. Ibid. 1-10 (Contrib. Gray Herb. x., in part).

[with J. M. Greenman.] A Revision of the Genus Zinnia. Ibid. 14-20 (Contrib. Gray Herb. x., in part).

[with J. M. Greenman.] Synopsis of the Mexican and Central American Species of the Genus Mikania. Ibid. 10-13 (Contrib. Gray Herb. x., in part).

The Herbarium. Ann. Rep. of the President and Treasurer of Harvard College, 1894-95. 189-193.

1897

[Review.] A Revision of the Genus Silene; by Frederic N. Williams. Bot. Gaz. xxiii. 135-138.

Case of Ecblastesis and Axial Prolification in Lepidium apetalum. Ibid. xxiv. 209-212, pl. 9.

The Official Nomenclature of the Royal Botanical Garden and Museum of Berlin. Ibid. 107-110.

[with W. Deane.] Viburnum Demetrionis. Ibid. 436.

The Publication of New Binomials in Works of Composite Authorship. Erythea, v. 127, 128.

[Review.] Pfaff's Observations on the Nature of Ivy Poisoning. Amer. Nat. xxxi. 901-903.

Synoptical Flora of North America. Vol. I. Fascicle ii. Continued and edited by Benjamin Lincoln Robinson. x-xv. and 208-506.

The Herbarium. Ann. Rep. of the President and Treasurer of Harvard College, 1895-96. 203-205.

1898

[Review.] Botanical Observations on the Azores; by William Trelease. Amer. Nat. xxxii. 128-130.

[Review.] Catalogo de Plantas Mexicanas (Fanerógamas); by Dr. Manuel Urbina. Ibid. 605, 606.

[Review.] Coastal and Plain Flora of Yucatan; by C. F. Millspaugh. Ibid. 461, 462.

[Review.] Floral Plan of the Cruciferae; by R. Chodat and A. Lendner. Ibid. 363-365.

[Review.] Garden-making; by L. H. Bailey. Ibid. 454-456.

[Review.] A New Botanical Journal. (Preliminary announcement of the monthly journal of the New England Botanical Club; by E. L. Rand). Ibid. 452-454.

[Review.] A New Check-list of North American Plants. (A Catalogue of North American Plants north of Mexico exclusive of the Lower Cryptogams; by A. A. Heller). Ibid. 459-461.

[Review.] Ninth Report of the Missouri Botanical Garden. Ibid. 528, 529.

[Review.] Porter's Translation of the "Bonn" Text-book of Botany. (A Text-book of Botany; by Strasburger, Noll, Schenk and Schimper). Ibid. 604, 605.

[Review.] A Review of Canadian Botany; by D. P. Penhallow. Ibid. 461.

[Review.] North American Lemnaceae. (A Revision of the American Lemnaceae occurring North of Mexico; by Charles Henry Thompson.) Ibid. 59, 60.

[Review.] Sur le genre Simmondsie; by Ph. Van Tieghem. Ibid. 529, 530.

A New Species of Apios from Kentucky. Bot. Gaz. xxv. 450-453, fig.

Some Reasons why the Rochester Nomenclature cannot be regarded as a Consistent or Stable System. Ibid. 437-445.

New Species and Extended Ranges of North American Caryophyllaceae. Ibid. 165-171, pl. 13.

Notes on the Genus Bartonia. Ibid. xxvi. 46-48.

[Review.] Revision of the Genus Arenaria; by F. N. Williams. Ibid. 289-291.

Revision of the North American and Mexican Species of Mimosa. Proc. Amer. Acad. xxxiii. 305-331 (Contrib. Gray Herb. xiii., in part).

Revision of the North American Species of Neptunia. Ibid. 332-334 (Contrib. Gray Herb. xiii., in part).

The Gray Herbarium. Ann. Rep. of the President and Treasurer of Harvard College, 1896-97. 208-210.

1899

An Apetalous Form of Arenaria groenlandica. Rhodora, i. 90.

Fairy Rings formed by Lycopodium inundatum. Ibid. 28-30.

A New Wild Lettuce from Eastern Massachusetts. Ibid. 12, 13, pl. 2.

Preliminary Lists of New England Plants, IV. Ibid. 212-214.

[Editor-in Chief.] Rhodora (Journal of the New England Botanical Club). 1899-1928.

[Review.] Illustrierte Flora von Deutschland; by A. Garcke. Amer. Nat. xxxiii. 79.

[Review.] Monographie der Myristicaceen; by O. Warburg. Ibid. 80, 81.

A Newly Observed Station for Galinsoga hispida. Bot. Gaz. xxviii. 216.

Revision of the North American Species of Tephrosia. Ibid. 193-202.

Three New Choripetalae from North America and Mexico. Ibid. 134-136.

Revision of the Genus Guardiola. Bull. Torr. Bot. Cl. xxvi. 232-235.

[with J. M. Greenman.] Revision of the Genus Gymnolomia. Proc. Boston Soc. Nat. Hist. xxix. 87-104 (Contrib. Gray Herb. xvii., in part).

[with J. M. Greenman.] Supplementary Notes upon Calea, Tridax and Mikania. Ibid. 105-108 (Contrib. Gray Herb. xvii., in part).

[with J. M. Greenman.] Revision of the Genera Montanoa, Perymenium and Zaluzania. Proc. Amer. Acad. xxxiv. 507-534 (Contrib. Gray Herb. xvi., in part).

[with J. M. Greenman.] Synopsis of the Genus Verbesina with an Analytical Key to the Species. Ibid. 534-566 (Contrib. Gray Herb. xvi., in part).

[with J. M. Greenman.] Wissadula tricarpellata Rob. & Greenm. Contrib. U. S. Nat. Herb. v. 179.

The Gray Herbarium. Ann. Rep. of the President and the Treasurer of Harvard College, 1897-98. 228-230.

1900

A Blue-fruited Huckleberry. Rhodora, ii. 81-83.

The Dwarf Mistletoe in New England. Ibid. 1, 2.

The Nomenclature of the New England Agrimonies. Ibid. 235-238.

Polygala polygama, var. abortiva merely an Autumnal State. Ibid. 242, 243.

Variations of Ilex verticillata. Ibid. 104-106.

[Review.] The last Contribution from the United States National Herbarium (vol. v.); chiefly by J. N. Rose. Amer. Nat. xxxiv. 74, 75.

New Phanerogams, chiefly Gamopetalae, from Mexico and Central America. Proc. Amer. Acad. xxxv. 323-342 (Contrib. Gray Herb. xviii., in part).

Synopses of the Genera Jaegeria and Russelia. Ibid. 315-321 (Contrib. Gray Herb. xviii., in part).

New Caryophyllaceae and Cruciferae of the Sierra Madre, Chihuahua, Mexico. Bot. Gaz. xxx. 58-60.

[Review.] A Synopsis of Mexican and Central American Umbelliferae; by J. M. Coulter and J. N. Rose. Ibid. xxix. 287, 288.

Sebastiana (?) bilocularis Wats. Erythea, vii. 189.

The Gray Herbarium. Ann. Rep. of the President and the Treasurer of Harvard College, 1898-1899. 235-237.

1901

Angelonia cubensis Robinson. Urban, Symb. Antill. ii. 458, 459.

Chloranthy in Anemonella thalictroides. Rhodora, iii. 205, 206.

Lycopodium clavatum var. monostachyon in Northern Maine. Ibid. 237, 238.

Self-strangulation in the Virginia Creeper. Ibid. 239, 240.

The Correct Disposition of Sisymbrium niagarense. Ibid. 16, 17.

The Identity of the Linnaean Gnaphalium plantaginifolium. Ibid. 11-13.

The North American Euphrasias. Ibid. 270-276.

Further Notes on the Agrimonies. Bull. Torr. Bot. Cl. xxviii. 295-300.

[Review.] The Flora of Cheshire; by Mr. Spencer Moore. Amer. Journ. Sci. ser. 4, xi. 398.

[Review.] Flora of Vermont (A List of Fern and Seed Plants growing without Cultivation); by E. Brainerd, L. R. Jones and W. W. Eggleston. Ibid. 249.

[Review.] Flora of Western Middle California; by Willis Linn Jepson. Ibid. 471, 472.

[Review.] Foundations of Botany; by Joseph Y. Bergen. Ibid. 248, 249.

[Review.] Grand Rapids Flora; by Emma J. Cole. Ibid. 472, 473.

[Review.] Monograph of the North American Umbelliferae; by J. M. Coulter and J. N. Rose. Ibid. 247, 248.

[Review.] A preliminary List of the Spermatophyta of North Dakota; by Henry L. Bolley and Lawrence R. Waldron. Ibid. 398, 399.

New Species and Newly Noted Synonymy among the Spermatophytes of Mexico and Central America. Proc. Amer. Acad. xxxvi. 471-488 (Contrib. Gray Herb. xx., in part).

Synopsis of the Genus Melampodium. Ibid. 455-466 (Contrib. Gray Herb. xx., in part).

Synopsis of the Genus Nocca. Ibid. 467-471 (Contrib. Gray Herb. xx., in part).

Problems and Possibilities of Systematic Botany. Address of the retiring President before the Botanical Society of America, at Denver, Colo. Science, n. s. xiv. 465-474.

The Gray Herbarium. Ann. Rep. of the President and the Treasurer of Harvard College, 1899-1900. 239-241.

1902

[Review.] A Botanical Survey of San Jacinto Mountain; by Harvey Munroe Hall. Amer. Journ. Sci. ser. 4, xv. 87.

[Review.] A Flora of the South Fork of King's River; by Alice Eastwood. Ibid. 86, 87.

Flora of the Galapagos Islands. Proc. Amer. Acad. xxxviii. 77-270, pls. 1-3 (Contrib. Gray Herb. xxiv.).

Further Stations for Veronica Chamaedrys. Rhodora, iv. 152.

Lechea major in New Hampshire. Ibid. 28.

The New England Polygonums of the Section Avicularia. Ibid. 65-73, pl. 35.

The Protection of our Native Flora. Ibid. 139-142.

Two New Hypericums of the Adpressum Group. Ibid. 135-137, pl. 37.

Veronica Chamaedrys in New England. Ibid. 107, 108.

The Gray Herbarium. Ann. Rep. of the President and the Treasurer of Harvard College, 1900-01. 222-224.

1903

Bewitched Buds. Boston Evening Transcript, Jan. 16.

Eupatorium hypomalacum (in Undescribed Plants from Guatemala and other Central American Republics; by John Donnell Smith). Bot. Gaz. xxxv. 4.

Further Notes on the Twelfth Preliminary List of New England Plants. Rhodora, v. 235, 236.

A Hitherto Undescribed Pipewort from New Jersey. Ibid. 175, 176.

Insecticides used at the Gray Herbarium. Ibid. 237-247.

Henry Griswold Jesup. Ibid. 191.

Preliminary Lists of New England Plants, XII. Ibid. 188-191.
Records of Wolffia columbiana in Massachusetts. Ibid. 287, 288.
The Generic Position of Echinodorus parvulus. Ibid. 85-89, pl. 45, figs. 1-10.
Viola arvensis in New England. Ibid. 155, 156.
[Review.] The Yucceae (in the Thirteenth Annual Report of the Missouri Botanical Garden); by W. Trelease. Amer. Nat. xxxvii. 74-76.
The Gray Herbarium. Ann. Rep. of the President and the Treasurer of Harvard College, 1901-02. 238-241.

1904

[with other Botanists of Harvard University.] Amendments to the Paris Code of Botanical Nomenclature suggested for Consideration of the Vienna Congress of 1905. Cambridge, Mass. 1-32.
Diagnoses and Synonymy of some Mexican and Central American Eupatoriums. Proc. Boston Soc. Nat. Hist. xxxi. 247-254 (Contrib. Gray Herb. xxvii., in part).
Synopsis of the Mikanias of Costa Rica. Ibid. 254-257 (Contrib. Gray Herb. xxvii., in part).
Notes on the Genus Mimosa in Mexico and Central America. Ibid. 257-261 (Contrib. Gray Herb. xxvii., in part).
Notes on some Polygonums of Western North America. Ibid. 261-265 (Contrib. Gray Herb. xxvii., in part).
New Spermatophytes of Mexico and Central America. Ibid. 265-271 (Contrib. Gray Herb. xxvii., in part).
[with J. M. Greenman.] Revision of the Genus Sabazia. Proc. Amer. Acad. xl. 3-6 (Contrib. Gray Herb. xxviii., in part).
[with J. M. Greenman.] Revision of the Mexican and Central American Species of Trixis. Ibid. 6-14 (Contrib. Gray Herb. xxviii., in part).
[with J. M. Greenman.] Revision of the Mexican and Central American Species of Hieracium. Ibid. 14-24 (Contrib. Gray Herb. xxviii., in part).
[Review.] Fragmenta Florae Philippinae; by J. Perkins. Amer. Journ. Sci. ser. 4, xvii. 481, 482.
A New Sheep-poison from Mexico. Bot. Gaz. xxxviii. 376-378.
[Review.] The Fourteenth Annual Report of the Missouri Botanical Garden. Ibid. xxxvii. 153, 154.
The Identity of Anychia dichotoma. Rhodora, vi. 50-53.
Notes on Publications recently Received. Ibid. 61-63.
Stellaria glauca established in the Province of Quebec. Ibid. 90, 91.
James Lawrence Bennett. Ibid. 146, 147.
[Review.] New England Ferns and their Common Allies; by Helen Eastman. Ibid. 211, 212.
The Problems of Ecology. Congr. Arts and Sci. Universal Exposition, St. Louis, Mo. v. Repr. 1-13.

[Review.] Praktikum für morphologische und systematische Botanik; by Karl Schumann. Science, n. s. xx. 564.
The Gray Herbarium. Ann. Rep. of the President and the Treasurer of Harvard College, 1902-03. 222-225.

1905

A Connecticut Station for Lycopodium Selago. Rhodora, vii. 20.
A New Ranunculus from Northeastern America. Ibid. 219-222.
Two Varieties of Sisymbrium officinale in America. Ibid. 101-103.
A Well Marked Species of Sparganium. Ibid. 60.
[Review.] The Fern Allies of North America north of Mexico; by W. N. Clute. Ibid. 267, 268.
Diagnoses and Notes relating to American Eupatorieae. Proc. Amer. Acad. xli. 271-278 (Contrib. Gray Herb. xxxi. in part).
The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1903-04. 236-240.

1906

Filipendula rubra, a New Binomial. Rhodora, viii. 202-204.
The Nomenclature of the New England Lauraceae. Ibid. 196-199.
Oxalis corniculata and its Allies. Journ. Bot. xliv. 386-391.
Studies in the Eupatorieae. I. Revision of the Genus Piqueria. II. Revision of the Genus Ophryosporus. III. The Genus Helogyne and its Synonyms. IV. Diagnoses and Synonymy of Eupatorieae and of Certain Other Compositae which have been classed with them. Proc. Amer. Acad. xlii. 3-48 (Contrib. Gray Herb. xxxii).
The Generic Concept in the Classification of the Flowering Plants. Address of the Vice-President and Chairman of Section G—Botany—at the New Orleans Meeting of the Amer. Assoc. Adv. Sci. Science, n. s. xxiii. 81-92. Proc. Amer. Assoc. Adv. Sci. lv. 417-435.
The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1904-05 (Official Reg. of Harvard Univ. iii. 236-240).

1907

New or otherwise Noteworthy Spermatophytes chiefly from Mexico. Proc. Amer. Acad. xliii. 21-48 (Contrib. Gray Herb. xxxiv., in part).
[with Harley Harris Bartlett.] New Plants from Guatemala and Mexico collected chiefly by C. C. Deam. Ibid. 48-60 (Contrib. Gray Herb. xxxiv, in part).
On the Rules of Botanical Nomenclature adopted by the Vienna Congress. Rhodora, ix. 29-55.
The Scientific Name of the Osage Orange. Ibid. 91.
Maclura pomifera (Raf.) Schneider. Ibid. 148.
The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1905-06 (Official Reg. of Harvard Univ. iv. 225-229).

1908

[Joint Editor with Merritt Lyndon Fernald.] Gray's New Manual of Botany. A handbook of the flowering plants and ferns of the central and northeastern United States and adjacent Canada. 1-926. Illus.

Notes on the Vascular Plants of the Northeastern United States. Rhodora, x. 29-35.

Further Notes on the Vascular Plants of the Northeastern United States. Ibid. 64-68.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1906-07 (Official Reg. of Harvard Univ. v. 221-226).

1909

[Review.] Bartonia. Rhodora, xi. 74.

[with M. L. Fernald.] Emendations of the Seventh Edition of Gray's Manual. I. Ibid. 33-61.

[Editor.] Botany. New Century Book of Facts, 630-657, 678-700.

[Review.] Essentials of Botany; by Joseph Young Bergen. Education, xxix. 473.

A Revision of the Genus Rumfordia. Proc. Amer. Acad. xliv. 592-596 (Contrib. Gray Herb. xxxvi, in part).

Diagnoses and Transfers of Tropical American Phanerogams. Ibid. 613-626 (Contrib. Gray Herb. xxxvi, in part).

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1907-08 (Official Reg. of Harvard Univ. vi. 231-236).

1910

[Review.] New Manual of Botany of the Central Rocky Mountains; by J. M. Coulter and Aven Nelson. Rhodora, xii. 13-16.

Notes on Recent Publications. Ibid. 56.

[Review.] Ornamental Shrubs of the United States; by Austin Craig Apgar. Ibid. 207, 208.

Spermatophytes, new or reclassified, chiefly Rubiaceae and Gentianaceae. Proc. Amer. Acad. xlv. 394-412 (Contrib. Gray Herb. xxxviii, in part).

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1908-09 (Official Reg. of Harvard Univ. vii. 221-226).

1911

Erucastrum Pollichii adventive in America. Rhodora, xiii. 10-12.

Notes on the Genus Cirsium. Ibid. 238-240.

On the Classification of Certain Eupatorieae. Proc. Amer. Acad. xlvii. 191-202 (Contrib. Gray Herb. xxxix, in part).

Revision of the Genus Barroetea. Ibid. 202-206 (Contrib. Gray Herb. xxxix, in part).

On Some Hitherto Undescribed or Misplaced Compositae. Ibid. 206-216 (Contrib. Gray Herb. xxxix, in part).

The Removal of an Old Landmark. Harvard Grad. Mag. no. 75, 418-421 and plate.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1909-10 (Official Reg. of Harvard Univ. viii. 184-188).

1912

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1910-11 (Official Reg. of Harvard Univ. ix. 173-177).

1913

A Key to the Genera of the Compositae-Eupatorieae. Proc. Amer. Acad. xlix, 429-437 (Contrib. Gray Herb. xlii, in part).

Revisions of Alomia, Ageratum and Oxylobus. Ibid. 438-491 (Contrib. Gray Herb. xlii, in part).

Diagnoses and Transfers among the Spermatophytes. Ibid. 502-517 (Contrib. Gray Herb. xlii, in part).

[Review.] Handbook of the Wild and Cultivated Plants; by Chester A. Darling. Rhodora, xv. 19, 20.

Erigeron pusillus a Valid Species. Ibid. 205-209.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1911-12 (Official Reg. of Harvard Univ. x. 173-177).

1914

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1912-13 (Official Reg. of Harvard Univ. xi. 180-184).

1915

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1913-14 (Official Reg. of Harvard Univ. xii. 189-193).

1916

A Notable Monstrosity of Arisaema triphyllum. Rhodora, xviii. 222, 223, fig. 1.

The Doctors John Brickell. Ibid. 225-230.

New, Reclassified or otherwise Noteworthy Spermatophytes. Proc. Amer. Acad. li, 527-540 (Contrib. Gray Herb. xlv, in part).

Cyrus Guernsey Pringle. Ibid. 912-916.

The Gray Herbarium. Harvard Alumni Bull. xviii. 355-357. Illus.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1914-15 (Official Reg. of Harvard Univ. xiii. 206-210).

1917

Joseph Young Bergen. Science, n. s. xlvi. 379, 380.

A Monograph of the Genus Brickellia. Mem. Gray Herb. i. 3-151, figs. 1-95.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1915-16 (Official Reg. of Harvard Univ. xiv. 212-215).

1918

Diagnoses and Notes relating to Tropical American Eupatorieae. Proc. Amer. Acad. liv. 235-263 (Contrib. Gray Herb. lv, in part).

A Descriptive Revision of the Colombian Eupatoriums. Ibid. 264-330 (Contrib. Gray Herb. lv, in part).

Keyed Recensions of the Eupatoriums of Venezuela and Ecuador. Ibid. 331-367 (Contrib. Gray Herb. lv, in part).

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1916-17 (Official Reg. of Harvard Univ. xv. 198-201).

1919

On Tropical American Compositae, chiefly Eupatorieae. Proc. Amer. Acad. lv. 3-41 (Contrib. Gray Herb. lx, in part).

A Recension of the Eupatoriums of Peru. Ibid. 42-88 (Contrib. Gray Herb. lx, in part).

An Unusual Daucus Carota. Rhodora, xxi. 70, 71.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1917-18 (Official Reg. of Harvard Univ. xvi. 196-201).

1920

Further Diagnoses and Notes on Tropical American Eupatorieae. Contrib. Gray Herb. lxi. 3-30.

The Eupatoriums of Bolivia. Ibid. 30-80.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1918-19 (Official Reg. of Harvard Univ. xvii. 156-160).

1921

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1919-20 (Official Reg. of Harvard Univ. xviii. 198-202).

1922

Records Preliminary to a General Treatment of the Eupatorieae, I. Contrib. Gray Herb. lxiv. 3-21.

The Mikanias of Northern and Western South America. Ibid. 21-116.

Dyscritothamnus, a New Genus of Compositae. (Contrib. Gray Herb. lxv. 24-28, pl.

Records Preliminary to a General Treatment of the Eupatorieae, II. Ibid. 46-54.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1920-21 (Official Reg. of Harvard Univ. xix. 235-239).

1923

Emily Frances Fletcher. Rhodora, xxv. 149, 150.

[with W. J. V. Osterhout and M. L. Fernald.] Minute on the Life and Services of Professor George Lincoln Goodale. Harvard Univ. Gaz. xviii. 198.

Records Preliminary to a General Treatment of the Eupatorieae, III. Contrib. Gray Herb. lxviii. 3-43.

The Need of Monographic Activity in American Botanical Taxonomy. A communication read before the Systematic Section of the Botanical Society of America. Science, n. s. lvii. 307-311.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1921-22 (Official Reg. of Harvard Univ. xx. 181-185).

1924

Mary A. Day. Science, n. s. lix. 205, 206.

Miss Day. Rhodora, xxvi. 41-47.

Records Preliminary to a General Treatment of the Eupatorieae, IV. Contrib. Gray Herb. lxxiii. 3-31.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1922-23 (Official Reg. of Harvard Univ. xxi. 221-225).

1925

Asa Gray. Science, n. s. lxii. 45, 46.

Count Solms (1842-1915). Proc. Amer. Acad. lix. 651-656.

Edward Lothrop Rand. Rhodora, xxvii. 17-27.

[Review.] Shrubs of Indiana; by C. C. Deam. Ibid. 15, 16.

Records Preliminary to a General Treatment of the Eupatorieae, V. Contrib. Gray Herb. lxxv. 3-15.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1923-24 (Official Reg. of Harvard Univ. xxii. 218-222).

1926

Records Preliminary to a General Treatment of the Eupatorieae, VI. Contrib. Gray Herb. lxxvii. 3-62.

The Woody Species of Eupatorium and Ophryosporus occurring in Mexico (in Standley, P. C.—Trees and Shrubs of Mexico). Contrib. U. S. Nat. Herb. xxiii. 1432-1470.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1924-25 (Official Reg. of Harvard Univ. xxiii. 209-213).

1927

George Lincoln Goodale, 1839-1923. Nat. Acad. Sci. xxi. sixth Memoir, 1-7, portrait.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College (Official Reg. of Harvard Univ. xxiv. 218-223).

1928

Concerning the Transmission of an Acquired Character in Flax. Science, n. s. lxvii. 242.

Records Preliminary to a General Treatment of the Eupatorieae, VII. Contrib. Gray Herb. lxxx. 3-42.

Sir Joseph Dalton Hooker (1817-1911). Proc. Amer. Acad. lxii. 257-266.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College (Official Reg. of Harvard Univ. xxv. 219-224).

1929

The Gray Herbarium at Harvard College. Harvard Alumni Bull. May 9, repr. 1-8.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College (Official Reg. of Harvard Univ. xxvi. 247-251).

1930

Ageratum (§Coelestina) Standleyi (in Standley, Woody Plants of Siguatepeque, Honduras). Journ. Arn. Arb. xi. 44.

Eupatorium (§Subimbricata) hondurense (in Standley, Woody Plants of Siguatepeque, Honduras). Ibid. 44, 45.

Botanical Legacies of Walter Deane. Science, n. s. lxxii. 459.

Botany, 1869-1929. (in Morison, Development of Harvard University since the Inauguration of President Eliot, 338-377).

Records Preliminary to a General Treatment of the Eupatorieae, VII. [Extract from Contrib. Gray Herb. lxxx, dealing with Peruvian plants.] Rev. Univ. Nac. Cuzco, xiv. 31-34.

Records Preliminary to a General Treatment of the Eupatorieae, VIII. Contrib. Gray Herb. xc. 3-36.

Observations on the Genus Stevia. Ibid. 36-58, plate.

The Stevias of the Argentine Republic. Ibid. 58-79.

The Stevias of Paraguay. Ibid. 79-90.

The Stevias of North America. Ibid. 90-160, pl.

[with Lesley Chillingsworth Wilcox.] The Gray Herbarium Card Index. Science, n. s. lxxi, 253-256.

The Gray Herbarium. Rep. of the President and the Treasurer of Harvard College, 1928-29 (Official Reg. of Harvard Univ. xxvii. 224-228).

1931

Compositae-Eupatorieae (of the Tyler-Duida Expedition). Bull. Torr. Bot. Cl. lviii. 482-485.

Emile Francis Williams. Rhodora, xxxiii, 1-18, portrait.

Portraits at the Gray Herbarium. Harvard Alumni Bull. Mar. 5, repr. 1-6, illustr.

Records Preliminary to a General Treatment of the Eupatorieae, IX. Contrib. Gray Herb. xcvi. 3-27.

The Stevias of Colombia. Ibid. 28-36.
The Stevias of Venezuela. Ibid. 37-43.
The Stevias of Ecuador. Ibid. 43-49.
The Gray Herbarium. Rep. of the President of Harvard College and Rep. of Depts. 1929-30 (Official Reg. of Harvard Univ. xxviii. 235-239).

1932

Records Preliminary to a General Treatment of the Eupatorieae, X. Contrib. Gray Herb. c. 3-19.
The Stevias of Peru. Ibid. 20-36.
The Stevias of Bolivia. Ibid. 36-69.
The Gray Herbarium. Rep. of the President of Harvard College and Rep. of Depts. 1930-31 (Official Reg. of Harvard Univ. xxix. 246-250).

1933

[Review.] Forest Trees of New England; by Robert Greenleaf Leavitt. Rhodora, xxxv. 108.
[with M. L. Fernald and W. H. Weston, Jr.] Minute on the Life and Services of Professor Roland Thaxter. Harvard Univ. Gaz. xxviii. 73, 74.
Taxonomic Notes on several South American Eupatoriums. Ostenia, 349-358, pls.
The Gray Herbarium. Rep. of the President of Harvard College and Rep. of Depts. 1931-32 (Official Reg. of Harvard Univ. xxx. 241-244).

1934

Records Preliminary to a General Treatment of the Eupatorieae, XI. Contrib. Gray Herb. civ. 3-49.
Mikania scandens and its near Relatives. Ibid. 55-71.
The Variability of Two Wide-ranging Species of Mikania. Ibid. 49-55.
New Compositae-Eupatorieae from Brazil. Candollea, v. 170-174.
The Gray Herbarium. Rep. of the President of Harvard College and Rep. of Depts. 1932-33 (Official Reg. of Harvard Univ. xxxi. 246-250).

1935

A New Species of Neurolaena from British Honduras. Rhodora, xxxvii. 61-63.
The Gray Herbarium. Rep. of the President of Harvard College and Rep. of Depts. 1933-34 (Official Reg. of Harvard Univ. xxxii. 272-277).

1936

Watson, Sereno. Dict. Amer. Biog. xx. 547, 548.

OBITUARIES AND NOTICES OF DR. ROBINSON

Death Claims 4 Leading Residents of Massachusetts over the Week-End. Boston Herald, July 29, 1935.

Dr. B. L. Robinson, Botanist, Dead. Ibid.

Dr. B. L. Robinson, Harvard Curator. (Notice of Death, also Obituary.) Boston Evening Transcript, July 29, 1935.

B. L. Robinson, Harvard Botany Professor, Dies. Hartford Courant, July 29, 1935.

Dr. Benjamin Lincoln Robinson. Jaffrey Recorder and Monadnock Breeze, Aug. 2, 1935.

B. L. Robinson, Noted Harvard Botanist, Dead. New York Herald-Tribune, July 29, 1935.

Benjamin Lincoln Robinson. Harvard Univ. Gaz. xxxi. 3, 1935.

Benjamin Lincoln Robinson. (Notice of Death.) Science, n. s. lxxxii. 94, 1935.

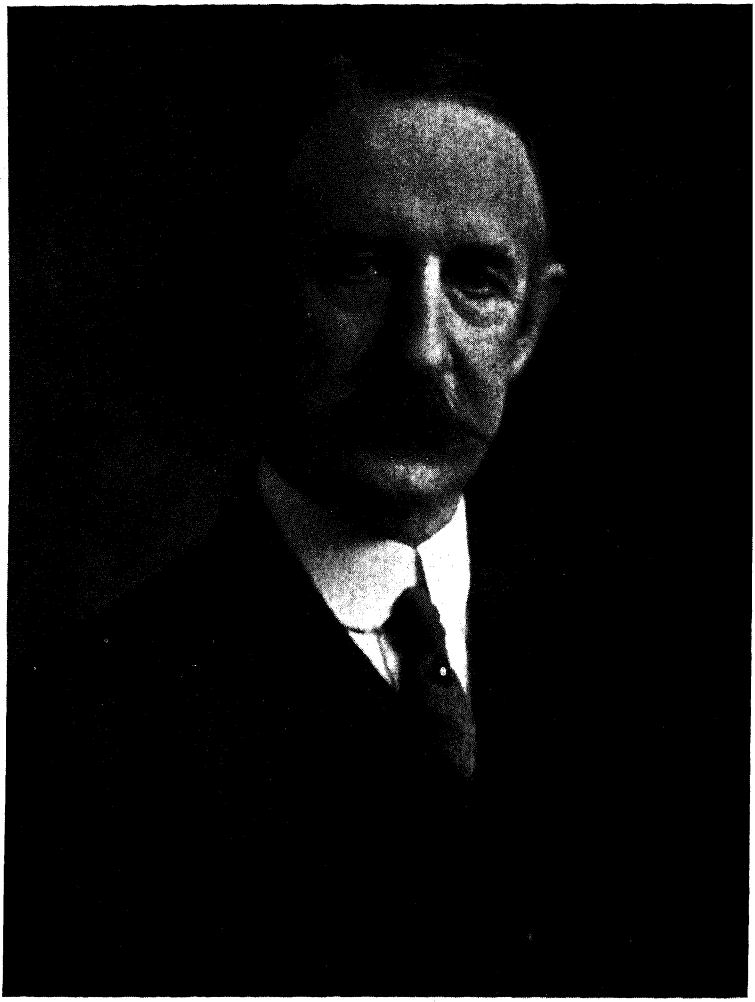
Benjamin Lincoln Robinson. (Obituary by) E. D. Merrill. Ibid. 142, 143, 1935.

Benjamin Lincoln Robinson. (Obituary by) A. B. Rendle. Journ. Bot. lxxiii. 300, 301, 1935.

B. L. Robinson. (Obituary.) Kew Bull. Misc. Inform. no. 10, 577, 578, 1935.

Benjamin Lincoln Robinson. (Minute presented to Faculty of Arts and Sciences, Harvard University, by) M. L. Fernald, C. A. Weatherby and I. M. Johnston. Harv. Univ. Gaz. xxxi. 107, 108, 1936.

Benjamin Lincoln Robinson. (Minute on Life and Work by) M. L. Fernald in Annual Report on Gray Herbarium. Rep. of the President of Harvard College and Rep. of Depts. 1934-35 (Official Reg. of Harvard Univ. xxxiii. 297, 298), 1936.



Geo. F. Swain

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVII—FOURTEENTH MEMOIR

BIOGRAPHICAL MEMOIR

OF

GEORGE FILLMORE SWAIN

1857–1931

BY

WILLIAM HOVGAARD

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1936

GEORGE FILLMORE SWAIN

1857–1931

BY WILLIAM HOVGAARD

Foreword

In July 1935 the writer was asked by the President of the National Academy of Sciences to prepare a memoir of George Fillmore Swain who died on July 1, 1931. The writer did not feel well qualified for this task, having had but little contact with Professor Swain either professionally or socially. Having to rely on indirectly acquired information, he was afraid that he would be unable to do justice to the memory of this remarkable man. For this reason he decided to base this memoir chiefly on one prepared by Professor Emeritus C. Frank Allen and Professor Albert Haertlein and published in the Transactions of the American Society of Civil Engineers.* That memoir was written by men who had an intimate knowledge of Professor Swain and his work. It is so complete and so excellent in form that it was felt by the writer that any attempt to improve upon it would be presumptuous on his part. With the kind permission of the authors it is given here in full.

BIOGRAPHY

George Fillmore Swain was born on March 2, 1857, in San Francisco, Calif. His ancestors came from New England. He was eighth in direct descent from Richard Swain who came to America in 1635 and settled first in Hampton, N. H. A few years later, Richard Swain moved to Nantucket, Mass., and was one of nine who in 1659 purchased the English rights to the entire island from Thomas Mayhew who, however, retained a twentieth interest. The Indian rights were also promptly acquired. Nantucket, in its prime, was the leader in whale fishery, and this not only bred sturdiness of character, but also brought prosperity with its many advantages. George Swain could trace his ancestry among many of the best known

* Vol. 98, pp. 1476 to 1484, 1933.

families of Nantucket, the names of Coffin, Macy, Starbuck, and Bunker being prominent among others.

His father, Robert Bunker Swain, was a native of Nantucket who moved to California in 1855, where he was engaged in the shipping and commission business. He became one of the leading merchants of San Francisco, served as President of the Chamber of Commerce, and also of the Mercantile Library Association. He was appointed Superintendent of the Branch Mint during President Lincoln's administration, and this work brought into play an unusual facility in the use of mathematics; the son's success in this direction had some root both by inheritance and example. The father's business position and his tastes led him to entertain many notable people, among them Camella Urso, distinguished violinist, Dr. Bellows, the leading Unitarian clergyman, and Mark Twain, whose stories from "Innocents Abroad" quite convulsed young Swain, who was allowed to listen from a near-by room. The elder Swain was an intimate of Starr King, well known in New England, and a power in holding California loyal in the Civil War. It is interesting to note that Bret Harte was his Secretary at the Mint.

George Swain relates that he was shy, timid, and without much physical courage or aggressiveness, and that his father to cure this had him take lessons in boxing and later in fencing. Quick in movement and perception, he became for a little chap expert with foils. When a school bully tried to pick on him he got his father's consent to fight him, used his boxing science, and was troubled no further. He also had to ride horseback, with horses not always too gentle, and thus learned to manage an unruly horse without fear and was never unseated. His father showed rare wisdom in these matters. Further, in preparation for college, he sent him to a military school, conducted under strict discipline, which included guard mounting, inspection, and other military requirements. Young Swain became a good shot at target practice. He served as Adjutant as well as Captain of a company and was the Valedictorian of his class. He rated his military training as one of the best things that ever happened to him. All these furnished a background

and were elements which contributed to make George Swain the man he was; he had an unusual start, both by inheritance and environment, from his father's side.

His mother, Clara Fillmore, born in Lynn, Mass., was a woman of refined literary tastes. She died while George Swain was still young. His grandfather was the Rev. Daniel Fillmore, a Methodist minister, who was twice assigned to a pastorate in Nantucket. His grandmother, Susan French Clark, born in Plymouth, Vt., also was of fine literary tastes. A small collection of her poems was printed; one of these, "The House I Live in," written by her on the occasion of her eighty-fifth birthday, had real merit. She lived to be nearly ninety-eight years old. At one time, she had kept a private school in Boston, Mass. His uncle, Dr. Charles Wesley Fillmore, was graduated from the Harvard Medical School in 1856 and studied further in Europe—in Paris, Berlin, Vienna, and elsewhere—specializing in eye and ear; on his return he became a surgeon in the Army and, later, engaged in practice in Providence, R. I. While in Europe Dr. Fillmore studied the violin successfully under some of the best masters, and this as well as his studies and life abroad furnished elements which afterward contributed to Professor Swain's success.

At the age of fifteen George Swain had decided to become an engineer, and not long after his father's death in 1872, he came East to his grandmother and his uncle, Dr. Fillmore, in Providence. He finally decided to enter the Massachusetts Institute of Technology at Boston, largely on account of its proximity to Providence. In some doubt as to adequate preparation in mathematics for the entrance examinations, he secured as a tutor a senior in Brown University; Benjamin Ide Wheeler, who later became President of the University of California. A letter from Dr. Fillmore was sent to Edward Everett Hale, who secured young Swain's boarding place in Boston. He was fortunate in the kind of people who became interested in him.

Not quite sixteen when he entered the Massachusetts Institute of Technology, he had a fine record of scholarship and was the ranking student of his class. He served as Adjutant of the

Military Battalion for which his earlier training well fitted him.

Among the studies pursued, the course in logic taught by Professor George H. Howison appealed to him, and he took this course as an extra subject. The taste for study along this line and the reading done in this direction he had always valued highly as an important part of his training. He was an omnivorous reader. Bryant's poetry specially appealed to him, as it had also to his mother, and Emerson did much for his philosophy. He developed a fondness for Shakespeare, and this, in connection with his logic, certainly was conducive not only to clear thought, but also to habits of clear expression, which a training in mathematics and science sometimes fails to secure.

His teacher in civil engineering was Professor John B. Henck, a fine mathematician, a strict and effective teacher who demanded and received good work from his pupils and did more than any other member of the early faculty to fix the high standards of this institution. His influence on Professor Swain's later teaching must have been very great.

In 1877, young Swain received the degree of Bachelor of Science in the Course of Civil and Topographical Engineering. Not satisfied with this, he spent three years abroad, primarily for the study of civil engineering, in which he did fine work, but with the added advantage to him of acquiring a breadth of view and experience in life, a wide acquaintance with men of various training, and an opportunity to travel, which together formed a most valuable feature of his life abroad. He thus secured something which cannot be acquired from travel alone. Among the acquaintances he formed while abroad the late Dr. Arthur T. Hadley is worthy of mention. He acquired also an almost perfect knowledge of German, and in his travels often registered from Berlin rather than from America, to his material advantage.

He studied at the Royal Polytechnicum, in Berlin, under such able masters as Winkler, Goering, and Hagen, specializing in bridges and other structures, railroads, and hydraulics, subjects valuable quite as much for training as for understanding of the work covered. With superior natural and demonstrated

ability, combined with an excellent foundation secured at the Massachusetts Institute of Technology, he was in a position to benefit well-nigh to the limit from the opportunities offered at the Royal Polytechnicum. At the close, he had substantially mastered the subjects of structural, hydraulic, and railroad engineering, and reached this country probably more highly trained in these subjects than any of his contemporaries.

Advanced degrees were then restricted to those who were to enter governmental service, so that he received no degrees; but the substance he secured. He did, however, bring away flattering recommendations from Winkler and Goering. While in Germany he visited many engineering works with his professors. He attributed much of his later success to his years abroad, and not solely to his training in engineering or his mastery of German. He took advantage of his opportunity to hear music by great masters. He played the piano with skill and taste, and on his return to America spent many evenings playing such music as Beethoven sonatas with his uncle, the violinist. It is probable that his uncle, who had been trained abroad, was responsible for young Swain's going to Germany to study.

On his return in 1880, he was appointed Expert Special Agent of the Tenth Census of the United States, investigating water power in connection with manufacturing interests. He presented reports on the Middle Atlantic and on the South Atlantic water-sheds, and, later, on the water powers of New England.

In 1881, he was appointed Instructor in Civil Engineering at the Massachusetts Institute of Technology. Gen. Francis A. Walker who had been Superintendent of the Census, was in the same year appointed President of the Institute. George Swain had served under him while engaged on the census, and the natural outcome was General Walker's early recognition of his abilities by his promotions to Assistant Professor in 1883 and to Associate Professor in 1886. He spent one summer with the Essex Company, at Lawrence, Mass., and another at Lowell, Mass., in the office of Locks and Canals under the late

James B. Francis, Past-President and Honorary Member American Society of Civil Engineers.

Early in 1887, occurred the widely known Bussey Bridge disaster. This furnished the first opportunity for Professor Swain to distinguish himself in the engineering field. At the investigation which followed, the quality of his training and his ability to analyze the causes of the accident so impressed the Railroad Commission of Massachusetts that he was appointed the first Expert Engineer of the Commission under a law newly passed, an office for which he was well fitted—one which he filled continuously and satisfactorily for many years, and which yielded him a rare experience. He examined and became responsible for more than 2000 railroad and electric railway bridges—a tremendous burden. He steadily and unostentatiously brought them into condition, securing the confidence of railroad officials, and thereafter no accident happened for which he could be held responsible in the slightest degree. He served in this position for twenty-seven years.

Although Professor Swain had been told that he was too young to become the head of the department of the Institute then vacant, the prestige of his railroad appointment led to his selection as Hayward Professor of Civil Engineering and head of the department at the age of thirty (an early age for conservative Boston); however, his success more than justified his appointment. A remarkable development followed. At the time when he became Acting Head of the department in 1887, he was the only full professor; there were three instructors and one assistant. In 1909, there were twenty members of the department, of whom ten were members of the faculty. In 1887, there was no department library worthy of the name; in 1909, it had become probably the best working library of civil engineering in the country, and it was due to his enthusiasm and judgment that this was accomplished.

While at the Massachusetts Institute of Technology he served for a time as Secretary of the Society of Arts connected with it, and for two years was Secretary of the Technology Alumni Association.

In 1909, Professor Swain was offered and accepted the Gordon McKay Professorship of Civil Engineering at what was then and for a time afterward the Graduate School of Applied Science, Harvard University. An important consideration in his acceptance was his expressed belief that this Graduate School marked an advance in the status of engineering, putting it on the same basis as law and medicine, the schools of which for some time had been on a graduate basis at Harvard. He held the Gordon McKay Professorship at Harvard until his death, becoming Emeritus in 1929 when impaired health prevented his active participation in the class-room.

As a teacher, Professor Swain's standards were high. He demanded from his students not only diligence and attention but, beyond that, insisted upon clear thinking on their part. His work was very thorough, of a high grade, and enforced by a steady drill in the principles of the subject. Mere acquirement of an understanding of the subject in hand was secondary to clear thinking along the line of work. He was a drillmaster *par excellence* in a subject which especially lent itself to such treatment. Perhaps no other man has contributed so much, so consistently, and for so long a period, to the development of correct methods of thought and high standards of scholarship in the field of engineering education.

He taught many subjects at the Massachusetts Institute of Technology in the early days, the important course in hydraulics being for several years in his direct charge. Later, he confined his attention almost exclusively to structures, which he taught not only to undergraduate students, but also to graduate students. Fate, in part through the Railroad Commission, seems to have decreed that both his teaching and his engineering activity should be largely in the field of structural work.

In 1893, men engaged in teaching engineering in the United States and Canada organized the Society for the Promotion of Engineering Education. Professor Swain was an early president of this Society, in which he took for many years an active part. His attitude toward the work of teaching was well defined in his presidential address on "The Profession of En-

gineering Teaching," in which he called attention to the necessity that professors of engineering should cultivate the teaching side, however attractive the engineering side might be. In his annual address * as President of the American Society of Civil Engineers, he said:

"Our teachers are generally, I think, chosen upon an incorrect principle; they are appointed by reason of what they know; it seems to me they should be selected for what they are—for their ability to teach, and their power of enforcing scientific discipline."

This attitude toward teaching, shared by his colleagues in the department, meant much to the success of his administration. His reputation among the teachers of the country placed him in the first rank. This is attested by the fact that the Society for the Promotion of Engineering Education in 1928 made him its choice as the first recipient of the Lamme Medal, awarded yearly for "accomplishment in technical teaching or actual advancement in the art of technical training." This medal, Professor Swain valued most highly.

As an engineer and as an official in connection with engineering work, he had a large and successful experience. Aside from his duties with the Railroad Commission, he served as consulting or designing engineer for a number of bridges, movable as well as fixed, an unusual case being the reconstruction of the old chain suspension bridge at Newburyport, Mass., as a stiffened cable suspension bridge with a hinge at the center and with reinforced concrete towers.

In 1894, the Boston Transit Commission was organized to construct the Boston subways. Professor Swain was one of the first commissioners appointed. He served on it for twenty-four years and was its chairman for five years. The work was without precedent in this country, was well carried out, and within the original estimates. The Tremont Street Subway

---

* "Some Tendencies and Problems of the Present-Day and the Relation of the Engineer Thereto": Address at the annual convention, Ottawa, Ont., Canada, June 18, 1913, by George Fillmore Swain, President, American Society of Civil Engineers, *Transactions*, Am. Soc. C. E., Vol. LXXVI (1913), p. 1112.

was the first under-street subway in the United States. The tunnel under Boston Harbor to East Boston was a part of the work of this Commission, as was also the Charlestown Bridge. The expenditure by the Commission during Professor Swain's years of service was in excess of $30,000,000.

He served upon approximately twenty commissions in Massachusetts to fix the method of eliminating grade crossings of highways with steam railroads, those of Worcester, Taunton, Newton, and Waltham, being among the most important. He was a member of the Commission to revise the Building Laws of Boston. He was also frequently called upon as an expert in court cases, not only in Massachusetts, but elsewhere.

Professor Swain served as expert for the State Commission on the valuation of the assets and liabilities of the New York, New Haven and Hartford Railroad Company. This involved appraisals of properties and securities held by the railroads, a physical valuation, a consideration of economic problems, and a critical examination of books. He was in charge of the Royal Commission on Railways and Transportation of Canada, involving 13,000 miles of Canadian railways. He directed similar valuations of other railroads, both large and small, among which were the Chicago Elevated Railways as well as the New York Central Railroad. Altogether, these valuations ran up to many hundreds of millions of dollars.

In 1908, he was appointed by President Theodore Roosevelt a member of the Inland Waterways Commission and also of the Conservation Commission. This followed the hearings of a Congressional Committee upon the proposed Appalachian Forest Reserve, at which Professor Swain took an important part.

In 1918, he was one of the representatives of the American Society of Civil Engineers, as part of a delegation of nine from the four Founder Engineering Societies of the United States, to confer with French engineers regarding the adoption of a program for the rehabilitation of France. He served as secretary of the delegation as well as chairman of two of the sub-committees during a stay in France of about one month.

He was also a member of the Franco-American Engineering Commission organized in 1919.

For a number of years he was a member of the Board of Judges to select names for the Hall of Fame, at New York University, and this University, in 1906, conferred upon him the honorary degree of Doctor of Laws.

During the celebration of the fiftieth anniversary of the founding of the University of California in 1918, he delivered the Hitchcock Lectures. There was then conferred on him the honorary degree of Doctor of Laws by President Benjamin Ide Wheeler, his former tutor in Providence, who must have had great satisfaction in conferring the degree upon his former pupil. Professor Swain was much gratified at receiving this honor from the State University of his native State.

In 1914, he delivered the Charles S. Lyman Lecture, at Yale University. He chose for his title "The Conservation of Water by Storage." This was published in book form by the Yale University Press.

There were early publications on hydraulics and on structures for the use of his classes; they were highly regarded, but were not given general circulation. The *Journal* of the Franklin Institute for 1882 and 1883 contains articles by him on "Mohr's Graphical Theory of Earth Pressure" and on the "Application of the Principle of Virtual Velocities to the Determination of the Deflection and Stresses of Frames"; in 1887 he contributed a paper to the American Society of Civil Engineers, "On the Calculation of Stresses in Bridges for the Actual Concentrated Loads," * a feature of which was the use of "influence lines," and in March, 1919, a paper, "On a New Principle in the Theory of Structures." ** The three last-mentioned papers have had a very material effect upon present practice in structural computations and investigations. He was active in contributing papers to various societies, and many official reports were made by him, sometimes individually, sometimes as a member of a board.

Late in life, he brought to the point of publication three

* *Transactions*, Am. Soc. C. E., Vol. XVII (1887), p. 21.

** *Loc cit.*, Vol. LXXXIII (1919-20), p. 622.

volumes of a treatise upon which he had worked intermittently for thirty years. The first volume on "Strength of Materials" was published in 1924, as was also the second volume, "Fundamental Properties of Materials." The third volume, "Stresses, Graphical Statistics and Masonry," was published in 1927. His sudden illness delayed and perhaps prevented the completion of the remaining volumes, which, in manuscript, are nearly finished. As might be expected, these books were of monumental character, and of great value to the profession. His book on "How to Study" (1917), has had a wide and continuing circulation, being required as a part of the engineering course in a number of colleges. A somewhat later book, "The Young Man and Civil Engineering," was one of a series touching various occupations or professions, and was well received.

Professor Swain was a member of many engineering or allied societies, including: Boston Society of Civil Engineers, of which he was President and Honorary Member; New England Water Works Association; American Society of Mechanical Engineers; American Institute of Consulting Engineers; American Society for Testing Materials; Canadian Institute of Engineers; Institution of Civil Engineers of Great Britain; Society of Engineers of Hanover, Germany; American Railway Engineering Association; New England Railroad Club; National Academy of Sciences; American Association for the Advancement of Science, of which he had been a Vice-President; American Academy of Arts and Sciences; American Forestry Association; and Society for the Promotion of Engineering Education, of which he was Senior Past-President.

Perhaps the highest honor to which a civil engineer may aspire is the presidency of the Society, and to this post Professor Swain was elected in 1913, the first professor of engineering to be so honored. This qualification was doubtless a factor in his selection, although this was justified either by his standing as an engineer or because of faithful and efficient work within the Society.

He had long been of the opinion that activity in the Society

should precede rather than follow election. By this standard, he qualified well. He had contributed papers to the Society, had served on its important committees, had been an influential member of its Board of Direction, and a Vice-President. Additional distinctions came from his elevation to Honorary Membership in 1929. At this ceremony, which occurred at the annual meeting, in New York, N. Y., on January 15, 1930, he was introduced by Hardy Cross, Member American Society of Civil Engineers, with the following remarks:

"Bred of stock which made New England famous, educated in that school of great engineers, the Massachusetts Institute of Technology, he brought to his life work a firm foundation of training and of character. I need not itemize his long career of service to his profession, to his Alma Mater, to Harvard University, to the City of Boston, to the Commonwealth of Massachusetts, and to our nation. His record is well known to you. You know especially of his services to this Society, through its publications, on its committees, and in administrative work. As an author he has given us a model of clear, precise, and forceful style. As a scholar he has been honest and accurate in detail and broad in vision. As an engineer he has shown discrimination in the choice of appropriate tools of thought and resourcefulness in application to engineering work. As a teacher he has been preeminent in his ability to inspire men and to train them.

"This man, this teacher, is no mere academic pedagogue. He was a man who never permitted mazes of mathematics and mazes of statistics to befog the vision of the men who studied under him. He was a prophet, a priest of clear individual thought and aggressive individual judgment."

Professor Swain had been a pronounced believer in the advantage to engineers of associating more largely with business and professional men not engineers. His presidential address to the Boston Society of Civil Engineers dealt with this subject; and, consistently, he had been a member in Boston of the Union Club, a general social organization; the St. Botolph Club, where literary or similar qualification is necessary; the Boston Art Club, for which he could qualify as a musician; the Commercial Club, whose name indicates its business character; and the Bos-

ton City Club, very cosmopolitan in character. He was also a member of the Harvard Club, the University Club, and the Unitarian Club, a denominational dining club that meets monthly.

Neither was he averse to recreation. He enjoyed whist and billiards, at both of which he played a good game. He was also, as has been stated, fond of music, and played the piano with skill and taste. It was his habit to do things well.

Professor Swain had a fine library, not only of scientific and professional books, but also along varied lines, including economics as well as general literature which appealed to him. His library contained many books in German and French, and he read freely in both languages, both as literature and as scientific treatises.

He was thrice married; to Katherine Kendrick Wheeler, who died in 1901; to Mary Hayden Lord, who died in 1914; and to Mary Augusta Rand, who survives him, as do also his daughters, Barbara and Clara, and a stepdaughter, Alice Rand.

Professor Swain's success may be attributed in part to inherited ability and fine environment at home and at school, both here and abroad; a training extended beyond that secured by most of his fellows; an orderly habit in his work and economy of effort, avoiding waste; a faculty for clear thought and clear expression; a remarkable capacity for hard, rapid, and concentrated work, together with an appreciation of "short-cuts" and effective methods. He possessed the valuable faculty of taking advantage of his opportunities, the lack of which talent has spelled failure to many otherwise able men.

It is not easy to record the sense of personal loss felt by his many friends who held him in high esteem. Many who visited him in his last sickness will rejoice that the honors so much appreciated by him, the Lamme Award and the Honorary Membership in the Society, happily came to him as a meed of cheer as the sun was slowly setting upon an active, well-spent, and useful life. He died July 1, 1931, at his summer home in New Hampshire.

Professor Swain was elected an Affiliate of the American

Society of Civil Engineers on September 5, 1883; a Member on March 2, 1892; and an Honorary Member on October 7, 1929. He was elected and served as a Director from 1901 to 1903; Vice-President, in 1908 and 1909; and President, in 1913.

While the writer of the present memoir is unable to add anything of his own knowledge to Professor Allen's and Professor Haertlein's account, he has thought it proper to add a few characteristic notes extracted from letters received from another of Professor Swain's former colleagues and from one of his former students.

FROM A FORMER COLLEAGUE *

"I knew Professor Swain as intimately, perhaps, as anyone outside his family circle, from my student days up to the time he died, a period of about thirty-five years. Together we worked on many problems connected with consulting and general engineering. I also knew him in his home and when, toward the close of his life, he was confined to his bed, I saw much of him and learned more about the man than I had known before.

"I was always much impressed and fascinated by his brilliancy, by his keen analytical observations, and his logical methods of deduction. These qualities he constantly endeavored to inculcate in his students, and his whole method of teaching was centered on this aim. Logical reasoning was constantly emphasized, and I well remember his earnest recommendation that we procure copies of Jevon's 'Logic' and master its contents.

"His mental processes were made in seven league boots compared with the slow, painful steps of the average man. His mind seemed to grasp the whole without having to assimilate the parts. His brilliant mental flashes in the classroom often dismayed the plodding student, but they succeeded in awakening his dormant faculties and aroused the pupil to greater efforts.

---

* Professor Geo. E. Russell, Massachusetts Institute of Technology, Cambridge, Massachusetts.

His mind was quite mathematical and his mental arithmetic was often most entertaining. I have seen him square numbers of three or four figures in as short a time as I would obtain the result on a slide rule. In fact, he had little use for a slide rule, claiming that it robbed him of just so much mental exercise.

"He continually exhorted his students to keep their minds 'fluid'. 'When you meet a seeming obstacle in analysis,' he would say, 'let your minds flow around the problem, viewing it from all sides. Don't let it be thick like molasses.' He practiced this preachment and it was interesting to see him attack a knotty problem. He would follow a line of reasoning leading to no solution, and then quickly abandon it for a wholly new approach. He never allowed his mathematical processes to blind his judgment. Constantly was he warning that common sense must sit as judge upon all mathematical conclusions. He was very fond of saying that 'common sense' should be called 'uncommon sense.'

"He was an avid reader and performed the difficult feat of keeping abreast with current events, sifting the contents of professional journals and, at the same time, dipping deep into history, biography and fiction. During his last sickness he could do nothing else but read and it was amazing to see the volumes that he devoured. I think he told me that he had read one hundred and twenty-five volumes during a period of three months.

"Some idea of him as a teacher may be gained from his little book on 'How to Study' which appeared in 1917 from the press of the McGraw-Hill Book Company. Crammed into less than seventy pages are many of the fundamental ideas he held on the art of studying. He was a very able writer and his books are models of careful arrangement and exposition.

"Before me, as I write, is the open page of a set of notes on structures written by him and used as a textbook. On the margins of the pages I find penciled notes of his last talk to the class. They refer to the essential things entering into the making of a successful engineer.

" 'Four things are necessary for success

1. Knowledge
2. Experience
3. Judgment
4. Character

" 'To get the first two, read transactions of engineering societies and professional papers; listen to experiences of others; keep notes; accumulate data; keep studying, —all branches.

" 'Train judgment by watching others. Have no opinion without a base to rest it on.

" 'Character,—most depends upon character. Persevere, —it is very important. Obey orders; keep your mouth shut; be reliable and truthful.

" 'Be careful of personal appearance and personal address.

" 'Success is to make the most out of life possible. It does not mean money.

" 'Never doubt your ultimate success.

" 'If you ask a favor, make it easy to answer it.

" 'Don't be over-confident.'

"Truly a great sermon in a few words."

FROM A FORMER STUDENT *

"Professor Swain was an unusual man. He was the finest teacher that I ever had, whether at Johns Hopkins, at Massachusetts Institute of Technology or at Harvard. I had already studied logic at Hopkins, but Professor Swain taught me how to use it, so far as I am capable of doing.

"He was always rigorous; he had little use for a student who came to class unprepared. His notes were mimeographed, and all of the mistakes were left in them, uncorrected, to catch the boy who did not use his mind when studying them. He was never content that his students should merely learn from notes or from books, but required individual thinking. His examination questions always contained some problem which had not been touched upon, either in the notes or in class, and which required thought.

* W. Watters Pagon, Member American Society of Civil Engineers, Consulting Engineer, Baltimore, Maryland.

"I thought so well of him that, when I had been out of college two years and had found how little I really knew, I followed him to Harvard. His methods were original, and he taught me something of originality.

"His most valuable instruction to his students was, I believe, his inculcation of the single idea that when one knows thoroughly the fundamental principles of a subject, he stands on a rock foundation. Many times when I have been giving expert testimony this teaching has given me the courage and sureness to stand up under heavy assaults. Further, having been imbued at Johns Hopkins with the spirit of research and having been persuaded by eminent scientists of the truth of its motto, 'Veritas vos liberabit', I was fertile ground for the sowing of his fearless spirit of adventure and pioneering from a known country of principles to a wilderness of fascinatingly unknown facts and ideas.

"Not many, I believe, of his students knew the more tender side of his nature. He permitted me to see some of it. He always showed some interest in me personally, and I can bear witness to the fact that he possessed a very warm heart. No one of course can overrate his high degree of personality.

"In my fifty years I have known few men of whom I can speak so highly and so fondly as of Professor Swain. His death was a sad loss to the professions of teaching and of civil engineering."

BIBLIOGRAPHY

Books

1914

Conservation of Water by Storage. Yale University Press.

1917

How to Study. McGraw-Hill Book Company.

1922

The Young Man and Civil Engineering. Macmillan.

1924

Structural Engineering—The Strength of Materials. McGraw-Hill Book Company.

Structural Engineering—Fundamental Properties of Materials. McGraw-Hill Book Company.

1927

Structural Engineering—Stresses, Graphical Statistics and Masonry. McGraw-Hill Book Company.

PAPERS IN THE TRANSACTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

Report of Progress of the Committee on the Compressive Strength of Cements and the Compression of Mortars and Settlement of Masonry. Vol. XV, p. 717 (1886); Vol. XVII, p. 213 (1887); Vol. XVIII, p. 264 (1888).

On the Calculation of the Stresses in Bridges for the Actual Concentrated Loads. Vol. XVII, p. 21.

Translation of paper by G. Kecker. Vol. XXIX, p. 491.

Progress Report of Special Committee on Steel Columns and Streets. Vol. LXVI, p. 401.

Final Report of the Special Committee on Uniform Tests of Cement. Vol. LXXV, p. 665.

Some Tendencies and Problems of the Present Day and the Relation of the Engineer Thereto. Address at the Annual Convention in Ottawa, Ontario, June 18,1913. Vol. LXXVI, p. 1112.

Specifications and Methods of Tests for Portland Cement. Vol. LXXXII, p. 166.

On a New Principle in the Theory of Structures. Vol. LXXXIII, p. 622.

Final Report of the Special Committee on Steel Columns and Streets. Vol. LXXXIII, p. 1583.

VARIOUS ADDRESSES AND SCIENTIFIC PUBLICATIONS

Address as chairman of the section of engineering of the American Association for the Advancement of Science.

Engineering education. Amer. Soc. Civil Eng., vol. 57.

Forests and rainfall. Trans. New England Water-Works Association.

Notes on hydraulics. Mass. Inst. Tech.

Notes on the theory and design of structures. Mass. Inst. Tech.

Reports on grade crossings and accidents. Repts. Mass. Railroad Commission.

A general formula for the normal stress in beams of any shape. Van Nostrand's Magazine, 1880.

Reports on water power, Atlantic coast of the United States. U. S. Census Repts. for 1880.

Mohr's graphical theory of earth pressure. Journ. Franklin Inst., 1882.

Application of the principle of virtual velocities to the determination of deflection and stresses of frames. Journ. Franklin Inst., 1883.

Steam railroad and street railway bridges in Massachusetts. Repts. Mass. Railroad Commission, 1887-1914.

Reports of the Boston Transit Commission from 1894 to 1918. (With others.)

Address as president of the Society for the Promotion of Engineering Education. Proc. Soc. Promotion Eng. Educ., 1895.

The status of the engineer. Address as president of the Boston Society of Civil Engineers, 1896.

The historical development of stone bridges. Journ. Assoc. Eng. Soc., 1896.

Some observations regarding the value of mathematics to the civil engineer and on the teaching of that subject to civil engineers. Paper presented to the Mathematical Congress at Rome, Italy, 1908.

Limitations of efficiency in engineering education. Address at the opening of the Engineering Building of Union College, 1910.

Report on valuation of the New York, New Haven and Hartford Railroad Company made to the State Commission on Validation. Published by the State of Massachusetts, 1911.

Report on valuation of the Chicago elevated railways, 1912.

Considerations with reference to rapid transit in cities. Trans. Eng. Soc. of Western Pa., 1915.

Engineering education. Pan-American Engineering Congress, San Francisco, 1915.

Report on valuation of certain railways in Canada made to the Government Commission on Transportation. Published by the Government, 1917.

Principles of practice in engineering training. Harvard Alumni Bull., March 21, 1918.

The liberal element in engineering education. Engr. Education, Dec., 1918.